THE
STOCKFEEDER'S COMPANION

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BY

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PREFACE

SOME excellent books have been written on the subject of Foods and Feeding, but, generally speaking, the language employed is rather too technical to be readily understood by farmers in general, or even students at Farm Institutes; hence the writer has felt, for some time, that an attempt should be made to write in simpler language a small book on the various problems which either directly or indirectly affect the Stockfeeder. In fact, considerable pains have been taken to present the information in a way that will be really helpful to the feeder of stock. Another feature of the book is that the feeding trials referred to are almost entirely British. Matters of purely scientific interest have, as a rule, been omitted, and a new "approximate method" of building up rations, devised by the writer, has been introduced, which should be a great help to feeders.

Under the Fertiliser and Feeding Stuffs Act, it is necessary for the seller of artificially compounded foods to give on the invoice the minimum percentage of albuminoids and oil which the food contains; but after very careful study, the writer finds that it would be an enormous advantage to the farmer when purchasing

food, as well as when compounding rations, if the fibre content of the purchased food was also stated. When this fact becomes thoroughly appreciated,[1] an effort will no doubt be made to extend the Act so as to include fibre as well as albuminoids and oil in the guaranteed analysis. Meanwhile, one will need to rely on the average percentage of fibre found in the particular food, when making up rations, etc., although average analyses are often at considerable variance to the actual composition of a given consignment of the same kind of feeding stuff.

Generally speaking, the bulky part of the ration is produced on the farm, and is fed more or less *ad libitum*. The concentrated food, on the other hand, has to be purchased to a large extent; hence the importance of knowing which foods to buy in order to meet the deficiencies in the bulky food for the particular object in view. A good deal of space has therefore been devoted to the compounding of rations for different animals, so as to give the feeder as much help as possible in this direction.

There is much confusion in the minds of farmers as to the technical difference between crude albuminoids and true albuminoids. In practice, when albuminoids are mentioned on an invoice, the percentage refers chiefly to true albuminoids; hence it was considered best in a book of this kind to use

[1] It would appear that Kellner had considerable difficulty in arriving at the starch equivalents of foods rich in fibre. To overcome this, he used factors, which expressed the percentage of "full value" each food had for production purposes.

the term albuminoids for true albuminoids only, and the term nitrogenous matter or protein for crude albuminoids.

The general scheme of the book is to show the relation between plants and animals—how plants supply the needs of the animal; then, after giving a full description of the foods available, to show how they may be utilised in a rational and economical manner for the feeding of farm live-stock. Many points have been dealt with which are not ordinarily found in books on Foods and Feeding, because they have an indirect if not a direct bearing on the subject.

The writing of this book has involved much laborious calculation in order to present some of the tables in a form which would be readily understood, as well as careful study of the reports of feeding trials carried out in Great Britain, many of which are specially referred to; and although the book may have many shortcomings, it is hoped that it will be really helpful to the feeders of stock and at the same time useful to students in Agricultural Colleges.

In conclusion, I must express my thanks to Dr Crowther for allowing me to include two very important tables which he has compiled on the average composition of farm foods and manurial constituents of the same; also to Messrs Edward Porter, B.Sc., F.A.C. (Glas.), James Mackintosh, O.B.E., N.D.A., and Allan S. M'William, B.Sc., N.D.A., N.D.D., who have

given me valuable assistance in revising the proof sheets, and have made several useful suggestions.

I must also acknowledge with thanks the readiness with which the Ministry of Agriculture has lent me books bearing on the subject from its library.

JOHN PORTER.

CROMHAMSTONE, NR. AYLESBURY,
November 1926.

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LIST OF ILLUSTRATIONS

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The Stockfeeder's Companion

I. THE ROUND OF NATURE.

THE soil, the air, and the plant are closely related in the production of food material for the Animal Kingdom. Generally speaking, the roots of the plant ramify the surface soil, and, through their root-hairs, absorb the minerals which have been dissolved in the soil-water. Above-ground the leaves of the plant are bathed in an atmosphere containing the necessary oxygen and carbon dioxide gases, which play such an important part in the life-history of the plant.

The development of green plants, however, is apparently impossible, even when the minerals of the soil are present in suitable form, and there is a sufficient supply of air, more especially for the leaves, unless the energy, at present supplied by the sun, is available to elaborate these simple substances into the more complex substances which form the tissues of plants.

It is in this way that plants, while laying up a store of food material for the propagation of their kind, unintentionally manufacture food for the Animal Kingdom. The animal body in its turn, after it has fulfilled its functions, becomes disorganised, its complex components break down into the simpler substances from which they have been built up, to

commence once again the same cycle of changes. This round is continually going on, and is daily revealing the wonderful power that exists in every green plant that possesses life, of utilising such unlikely materials as soil and air to build up food material for the Animal Kingdom.

Relation of Plants to the Animal Kingdom.—All living things can be divided into two groups, viz.: (1) Animals and (2) Plants. As we study the lowest forms in each kingdom, the differences become smaller and smaller, until we arrive at a point close to the dividing line between these two kingdoms, where it is difficult to say whether a certain living thing belongs to the Animal or the Vegetable Kingdom.

All these living things have something in common, inasmuch as they are composed of small cells containing a jelly-like substance called protoplasm or "living matter." The latter term is very expressive, because without this substance there cannot, so far as we know at present, be any life. Living things generally have the power of reproduction; and in order to maintain their bodies and increase in size, it is necessary for them to receive nutriment in some form or other.

The higher forms of plants (*e.g.*, wheat, beans, etc.), however, differ from the higher animals (*e.g.*, horses, cattle, sheep, etc.) in the following respects:—

Animals.	*Plants.*
1. Cell walls composed of albuminous substance.	Cell wall composed of cellulose.
2. Interior of cell filled with protoplasm.	Interior of older cells not entirely filled with protoplasm.
3. Have powers of locomotion.	Generally fixed to the soil by roots.

	Animals.	*Plants.*
4.	Have no power of manufacturing food material, but must apparently receive their sustenance from food previously built up by the plant.	Have power of manufacturing complex organic compounds or food material from simple substances such as minerals, air, and water, in the presence of sunlight, provided the plant is green (*i.e.*, possesses chlorophyll).
5.	Inhale oxygen gas from the air, and exhale carbon dioxide gas from the lungs chiefly (Respiration).	Have the power of absorbing carbon dioxide gas and exhaling oxygen gas during sunlight, in addition to the process of respiration.

The last two distinctions are highly important, since they show us that the higher animals, at any rate, are absolutely dependent on the existence of plants, as the latter purify the air by absorbing large quantities of carbon dioxide gas, and at the same time build up food material for the Animal Kingdom. Without plants, the air would tend to become foul, and the Animal Kingdom either extinct, or its members would have to find some other mode of existence.

In civilised countries the provision of a sufficient supply of plants cannot be entrusted to nature altogether; hence it is necessary where animals are kept, either as the servants of man or to supply him with food, that he should co-operate with nature in the growing of plants, so as to provide an adequate, if not an abundant supply of plant-food for the requirements of domesticated animals.

It will therefore be convenient to describe more in detail how the various food constituents are manufactured by plants, before dealing with questions of animal nutrition.

II. ESSENTIALS OF PLANT GROWTH.

The exact way in which plants obtained their nourishment was up to the middle of last century quite a mystery, and it will be very interesting to note the chief stages in this discovery:—

Water.—In the days of alchemy, when only four elements were recognised—viz., fire, air, earth, and water—Van Helmont grew a willow tree in some soil in a tub, and the only thing he added was water. The tree grew fairly well, but as the soil was practically the same weight at the finish, he concluded that water was the source of food for plants.

Tilth in Soils.—Jethro Tull found, more especially with the wheat crop, that frequent horse-hoeing had a great effect on the yield of straw and grain; hence he concluded that if the soil were only made fine enough, the small particles would be taken up by the root-hairs.

Humus.—In 1800, Thaer of Halle held that the humus in the soil was probably the source from which plants derived their food; but Liebig asked how it was possible for humus to be the original food of plants, seeing that it was itself largely decaying vegetable matter.

Carbon.—In 1804, De Saussure pointed out that when a plant was burned in air, most of it disappeared, therefore he considered that the greater part of a plant must be derived from the air and water. This proved later on to be the case, for a Swiss scientist (Chas. Bonner) noticed that when certain green leaves were immersed in water, bubbles of gas sometimes appeared on the leaves. Priestley found that these bubbles were oxygen gas, and Ingenhaus that they only made their appear-

ance in sunlight; while Jean Sènèbier discovered that instead of these leaves taking in oxygen and breathing out carbon dioxide gas, as animals always do (respiration), they actually carried on during sunlight the reverse process, viz.: that of absorbing carbon dioxide gas and breathing out oxygen gas.

Minerals.[1]—Digby found that saltpetre gave wonderful results when applied to hemp plants, due, he thought, to this substance fertilising the air. Later on, Liebig propounded his great mineral theory, that the minerals in the soil were essential in the growing of farm crops.

In recent years this mineral theory has been followed up. Plants were grown in water to which was added most mineral substances found in the ash of plants, and it was found that the plants grew and matured. One by one these minerals were eliminated, until it was ultimately discovered that for the successful growth of plants it was necessary to supply in suitable form nitrates, sulphates, and phosphates of potash, lime, magnesia and iron, so far as the minerals are concerned.

Further trials with farm crops showed that, in ordinary farm practice, it was only necessary to supply in suitable form, nitrogen, phosphates, potash, and occasionally lime. Seeing that lime only needs to be applied every four to eight years, manures supplying nitrogen, phosphates, and potash are called "complete manures," so far as the mineral requirements of the plant go.

The above discoveries are all very important. Even to-day it is still necessary to supply farm crops with

[1] The term "minerals" is taken to include the nitrogen which the plant obtains from the soil in the form of salts (nitrates chiefly).

water and minerals, to work the soil in order to admit air and get a good tilth, as well as to keep a supply of humus in the soil as reserve plant-food, and as an absorbent for water.

Absorption of Minerals.—The minerals in the soil which are dissolved in the soil-water soak or diffuse through the very delicate walls of the root-hairs (osmosis). The solution then rises up the wood-vessels (xylem) in the plant till it comes to the leaves, where it is continually being lost by transpiration or vaporisation, with the result that the minerals, which were dissolved in the water, become gradually concentrated in the leaves. A further supply of water containing dissolved minerals is again drawn up into the leaves, and so the process goes on. Generally speaking, the warmer the weather, the more rapidly do the leaves transpire.

The power which plants possess of drawing water from the roots up to the leaves is most likely due to a number of forces acting simultaneously, viz. :—

(*a*) Root-pressure, or the force exerted on the liquids in the plant by the absorbing action of the roots. The root continues to absorb, with the result that this exerts a push from behind on the liquid previously absorbed.

(*b*) The vacua formed in the wood-vessels of the stem of the plant, due to the loss of water by transpiration ; as well as

(*c*) The osmotic force of the minerals in the leaves, etc.

All these forces are involved in the distribution of minerals to those parts of the plant where they are required.

III. MANUFACTURE OF FOOD MATERIAL BY PLANTS.

Carbohydrates.—It has been pointed out above that the green parts of plants, under certain conditions, actually absorb carbon dioxide gas and give off oxygen gas, hence this process is called "carbon dioxide assimilation," or "carbon fixation." This process is now known to be due to the green part of the plant (chlorophyll) having the power, under the influence of sunlight, of splitting up the carbon dioxide gas contained in the air, retaining the carbon and liberating the oxygen; the carbon is at the same time combined with water in the leaves to form carbohydrates, generally starch ($C_6H_{10}O_5$).[1]

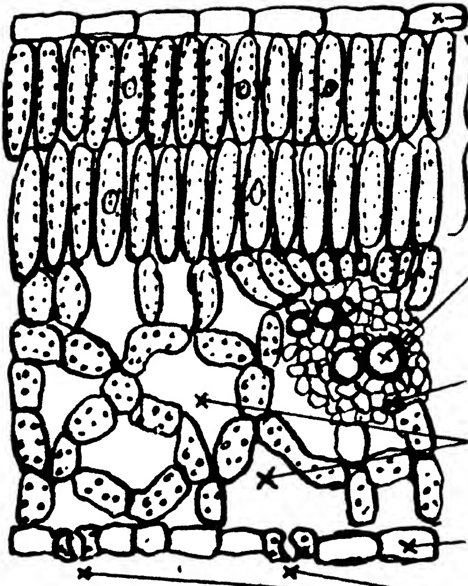
The formation of carbohydrates only proceeds as long as there is a suitable supply of minerals which the plant can secure from the soil, more especially potash and a little iron. These are absorbed and carried up to the leaves in solution, as mentioned above.

But how does the air get into the leaves? To understand this, one should know something of the structure of a leaf, which in flat leaves has on the underside a very large number of pores (stomata) which admit air, and at the same time allow gases and water-vapour to escape into the atmosphere. These pores admit air to the many cavities inside the leaf, and it is here that the carbon dioxide in the air dissolves in the cell sap. During sunlight the green colouring matter combines the carbon and the water together with the liberation of

[1] Professor Sachs found in a few cases that sugar, or even a fat, may be the first detectable organic product.

oxygen, which passes out by diffusion through the pores on the under-side of the leaves.

The starch ($C_6H_{10}O_5$) formed in the leaves is then converted into sugar ($C_6H_{12}O_6$) by a ferment in the



Transverse section of small part of a leaf of a dicotyledonous plant, greatly magnified, and rather diagrammatic.

leaf, and in this form diffuses or travels to those parts of the plant where growth is taking place, or to be stored up for future use, as in seeds, tubers, roots, fruits, etc. In cereal grains and tubers the sugar is again changed back into starch after it has arrived at its destination.

Fat or Oil.—Oil differs from fat in being liquid at ordinary atmospheric temperature, while fat is solid. They are both soluble in ether. These are formed from the carbohydrates, and it appears that a high temperature is necessary for the conversion of carbohydrates into fat or oil, seeing that flax seed (linseed) grown in hot countries (Russia) contains a much higher percentage of oil than that grown in colder climates (Ireland).

Fat and oil are made up of the same three elements as carbohydrates, but are characterised by having a very small proportion of oxygen in the molecule; or, to put it another way, fat is exceedingly rich in carbon.

Amides.—The sugar formed in the leaves is carried to all parts of the plant along vessels called the bast (phlœum). It is on this journey that the sugar comes in contact with the minerals, more especially the nitrates, when the living matter in the plant causes the elements of the sugar and the nitrates to combine, forming, probably, first ammonia (NH_3) and then an amide $\left(N\begin{matrix} \diagup H_2 \\ \diagdown CO \end{matrix}\right)$. The amides, therefore, contain nitrogen in addition to the three elements found in carbohydrates and fats. They are soluble in the cell sap, and are abundant in young, and especially so in luxuriant herbage.

Albuminoids.—As plants mature, the amides are gradually transformed into albuminoids (proteids). These differ chemically from amides in containing sulphur and sometimes phosphorus in addition to carbon, hydrogen, oxygen, and nitrogen. The albuminoids are largely stored in the seeds and fruits of plants.

Fibre.—This is often called woody fibre, on account of its indigestible properties. As the plant grows it requires more and more fibrous tissue to support its increase in size and weight, and for this purpose the plant utilises the carbohydrates (sugar). If the plant is allowed to get dead ripe, as is sometimes the case with cereals, the stem or straw consists almost entirely of woody fibre and becomes very brittle.

Ash Constituents or Mineral Matter.—These are taken up from the soil and later transferred to the seeds and the body of the plant generally.

The more the plant uses these minerals in the formation of foliage or seeds, the more freely will the minerals be absorbed by the roots from the soil.

Vitamins.—These are accessory food substances, which are found to a greater or less extent in most natural foods. Generally speaking, the ordinary methods of chemical analysis have failed to reveal their presence, hence they are dealt with under the functions of nutrients on p. 39.

IV. ESTIMATION OF NUTRIENT CONSTITUENTS IN PLANTS.

The nutrient constituents manufactured by plants are found to a greater or less extent, in most of the plants or parts of plants (seeds, etc.) which are fed to stock. Above we have noticed that albuminoids, amides, fats, carbohydrates, fibre, and ash are formed in plants, hence it is important to know how the chemist discovers the amounts of each of the nutrients contained in any given food-stuff, *e.g.*, oats, peas, beans, etc.

Before doing this, it may help the reader if the

nutrients of foods are classified in the following manner :—

- FOOD
  - . . . . Moisture.
  - Dry Matter
    - PROTEIN, Nitrogenous Matter or Crude Albuminoids
      - ALBUMINOIDS (Proteids).
      - Amides.
    - Non-nitrogenous Matter
      - OIL.
      - CARBOHYDRATES.
      - Fibre.
      - Ash.

The above nutrients are estimated as follows :—

Moisture.—The finely ground food is heated in a steam-oven till it ceases to lose weight; the loss on heating gives the amount of moisture in the food.

A rapid method of estimating the moisture content of cereal grains, etc., has recently been devised by Brown and Duvel of America. With their patent moisture tester the result may be obtained in half an hour. This is done by taking a certain weight of grain, placing it in a distillation flask with mineral oil, and distilling the water off. The steam driven off in this way, after being condensed, is led into a flask, which is graduated in such a way that the moisture content can be read off at once. The necessary temperature for distillation varies from 170° C. to 190° C., according to the particular seed or grain that is being tested.

Nitrogenous Matter (Protein).—A small quantity of the finely ground food is taken and heated with strong sulphuric acid to convert the organic nitrogen into ammonia. Caustic soda is then added to the solution, when the ammonia is distilled off and collected

into acid of standard strength. The amount of acid neutralised measures the ammonia which has been driven off, and from this the amount of nitrogen is calculated. Protein is found to contain on an average 16 per cent. of nitrogen, hence by multiplying the nitrogen in food by $6\frac{1}{4}$ ($\frac{100}{16}$), the amount contained in the food is obtained, and the percentage calculated.

The albuminoid part of the protein is precipitated when copper hydrate is added to a solution of protein, but the amides remain in solution. This precipitate contains only the albuminoids, and the estimation of the nitrogen is as above described. Hence if the protein (nitrogenous matter) is ascertained in a food, and the albuminoids also found in the same food, the difference will give the amides.

Oil.—This includes that part of the food which is soluble in ether, and on this account is more correctly called "ether extract." A known weight of the finely ground food is taken and treated with hot ether for probably a couple of hours to dissolve the oil out. The ether is then evaporated off, and the oil which is left behind is afterwards weighed. In bulky fodders this ether extract may include waxy matters, etc., in addition to oil, which makes the fat credited to these fodders less valuable for feeding purposes.

Fibre.—The food is boiled for half an hour in weak acid and then for half an hour in weak alkali; the part which still remains undissolved is called "fibre."

Ash or Mineral Matter.—The part which remains after the food has been burnt in the air till the residue ceases to lose weight is called "ash."

Carbohydrates include sugar, mucilage, starch, etc., and are obtained by ascertaining the total percentage of the above constituents and subtracting the aggregate

total percentage from 100. Hence they are obtained by difference.

V. COMPOSITION OF THE ANIMAL BODY.

The body of farm animals may be regarded as consisting of a bony skeleton, covered with an elaborate system of muscles. In addition, fat may accumulate between the individual fibres of these muscles and round the muscles generally, with the result that, as the animal fattens, the external covering of skin, with its appendages of hair, wool, etc., varies from time to time in size and shape.

Within this skeleton the vital organs are found, viz.: heart and lungs in front of the diaphragm (*i.e.* in the chest), and the stomach, liver, spleen, intestines, kidneys, etc., behind the diaphragm (*i.e.* in the abdomen). Each of these organs plays a very important part in animal nutrition.

The vascular system distributes the nutrients which have been absorbed into the blood, to every part of the body where it is required, either for maintaining the body temperature, repairing waste of tissue, supplying energy, or producing increase. The digestible parts of the food are thus utilised for the maintenance and development of the body, while the indigestible or unutilised part is removed from the system.

Briefly stated, the important "proximate" constituents of a fat animal from the butcher's point of view are: lean meat, fat, bone, and the skin. The proportion, arrangement, and quality of each of these constituents in the animal body, are problems which the breeder and purchaser of store stock have to keep constantly in mind.

In order to understand the practical side of feeding, it will be instructive and helpful to know something of the chemical composition of the animal body. Here one cannot do better than refer to the valuable work done by Lawes and Gilbert at Rothamsted Research Station (Hertfordshire, England), where the bodies of cattle, sheep, and pigs at different ages and varying stages of fatness were carefully analysed, and the following important data obtained.

The figures for the entire body of these farm animals are based on the fasted live weight, after the contents found in the stomach and intestines (varying from 3 to 9 per cent. of the weight of the animal) have been deducted. The latter precaution is very necessary before any comparisons can be made between the entire body and the carcass.

Composition of Entire Body and Dressed Carcass of Farm Animals.

Kind and Condition of Animal.	Entire Body.				Dressed Carcass			
	Water.	Protein.	Fat.	Mineral Matter.	Water.	Protein.	Fat.	Mineral Matter.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Fat calf	65·1	15·7	15·3	3·9	62·3	16·6	16·6	4·5
Half-fat ox	56·0	18·1	20·8	5·1	54·0	17·8	22·6	5·6
Fat ox	48·4	15·4	32·0	4·2	45·6	15·0	34·8	4·6
Fat lamb	52·2	13·5	31·1	3·2	48·6	10·9	36·9	3·6
Store sheep	61·0	15·8	19·9	3·3	57·3	14·5	23·8	4·4
Fat sheep	46·1	13·0	37·9	3·0	39·7	11·5	45·4	3·5
Extra fat sheep	37·1	11·5	48·3	3·1	33·0	9·1	55·1	2·8
Store pig	58·1	14·5	24·6	2·8	55·3	14·0	28·1	2·6
Fat pig	43·0	11·4	43·9	1·7	38·6	10·5	49·5	1·4

With these results before us, the following observations can be made :—

Water.—Generally speaking, water is the largest constituent of the entire body of farm animals, and in store or half-fat animals will often exceed half the weight of the body. In the case of the extra fat sheep and fat pig, the proportion of water in the body is actually less than that of the fat.

The bodies of young animals contain a larger proportion of water than older ones. Again, by comparing store and fat animals, it will be seen that, as fattening proceeds, the proportion of water in the body diminishes.

The proportion of water in the dressed carcass is from 2 to 6 per cent. less than that in the entire body.

Protein.—This consists in the "entire body" of lean meat (muscle), ligaments, tendons, skin, hair, hoofs, and horns (if present). Dried blood is also fairly rich in protein.

The proportion of protein tends to increase from youth to maturity (*cf.* fat calf and half-fat ox, or fat lamb and store sheep). As the animal fattens, the proportion of protein decreases. The largest proportion of protein is found in the body of the ox, while that in the pig is the smallest, although the proportion in the sheep is not much greater than that in the pig.

In the carcass the proportion of protein is about the same with the ox and the pig as in the entire body, but is 1 to 2½ per cent. less in the sheep.

Fat.—Fat forms a considerable proportion of the entire body. In fat animals this varies from one-third to almost one-half of the weight of the body. The proportion of fat is greatest in the pig and smallest in the ox (*cf.* fat sheep and fat pig).

The bodies of young animals contain a smaller pro-

portion of fat than older ones (*cf.* fat calf and fat ox, or fat lamb and fat sheep). As fattening proceeds, the proportion of fat increases very considerably; in fact, may amount to double that of the store animal (sheep).

In the "carcass" the proportion of fat varies from 1·3 to 7 per cent. in excess of that found in the entire body. The chief fats present in the carcass are stearin, palmatin, and olein; the last named being liquid at ordinary atmospheric temperature.

The Composition of Increase in Live Weight during fattening was calculated by Lawes and Gilbert for farm animals, with the following results:—

Kind of Animal.	Water.	Protein.	Fat.	Mineral Matter.
	per cent.	per cent.	per cent	per cent.
Ox	24·6	7·7	66·2	1·5
Sheep . . .	22·0	7·2	68·8	2·0
Pig	28·6	7·8	63·1	0·5

The chief points to notice are that two-thirds of the increase in live weight during fattening is fat, while only a fourteenth consists of lean meat (protein).

Mineral Matter (Ash).—This is concentrated to a large extent in the bony skeleton, although it is fairly abundant in muscle, blood, etc.

In the entire animal the proportion rarely exceeds 5 per cent. of the weight of the body, and is sometimes much less. The body of the ox is richest in minerals, and that of the pig poorest. The proportion diminishes as fattening proceeds.

The carcass is slightly richer in mineral matter than the entire body.

It will now be instructive to study in greater detail

the chemical composition of the mineral matter. It was with this object that Lawes and Gilbert determined the actual chemical constituents in the animal body, the results of which are given in the following table:—

Table showing Ash Constituents and Nitrogen in 1000 *lbs. of Farm Animals* (*Fatted Live Weight*), *Wool, and Milk.*

	Nitrogen (N).	Phosphoric Acid (P_2O_5).	Potash (K_2O).	Lime (CaO).	Magnesia (MgO).
	lbs.	lbs.	lbs.	lbs.	lbs.
Fat calf	24·64	15·35	2·06	16·46	0·79
Half-fat ox	27·45	18·39	2·05	21·11	0·85
Fat ox	23·26	15·51	1·76	17·92	0·61
Fat lamb	19·71	11·26	1·66	12·81	0·52
Store sheep	23·77	11·88	1·74	13·21	0·56
Fat sheep	19·76	10·40	1·48	11·84	0·48
Store pig	22·08	10·66	1·96	10·79	0·53
Fat pig	17·65	6·54	1·38	6·36	0·32
Wool (unwashed)	54·00	0·70	56·20	1·80	0·40
Milk	5·76	2·00	1·70	1·70	0·20

The above table shows that the half-fat ox per 1000 lbs. fasted live weight has removed from its food, and indirectly from the soil, an amount of minerals which would be supplied by 166 lbs. pure nitrate of soda, 133 lbs. superphosphate of lime (30 per cent. soluble), nearly 4 lbs. pure sulphate of potash, 26½ lbs. ground lime (80 per cent. pure), and nearly 2 lbs. carbonate of magnesia. These figures show that where young growing animals are living largely on pasture land, there is a considerable drain on the store of nitrogen, phosphates, and lime in the soil to supply the require-

ments of the animal body. Nitrogen may be collected from the air to a fairly considerable extent by the roots of clovers and other leguminous plants in the pasture, but this does not apply to minerals such as phosphates and lime. This explains why grass-land which has been grazed continuously with young cattle is apt to become destitute of these two substances; also why basic slag, which supplies both phosphates and lime, in many cases gives wonderful results when applied to such pastures. It is generally wise to include some kainit in the manurial mixture used on pastures, in case there might also be a shortage of potash.

In the same way, every store sheep of 100 lbs. live weight (which means a good big sheep) in building up its body has removed an amount of minerals from its food, and indirectly from the soil, equal to 14½ lbs. nitrate of soda, 8½ lbs. superphosphate of lime (30 per cent. soluble phosphate), ⅓ lb. pure sulphate of potash, and nearly 1¾ lbs. of ground lime (80 per cent. pure). If the sheep had been reared entirely on grass, the pasture would have lost the above amounts of minerals and nitrogen.

The ox requires a larger amount of minerals in proportion to its weight for its body requirements than either the sheep or the pig; and the pig requires less in proportion to its size than the sheep.

The large amounts of nitrogen and potash in unwashed wool are both very striking. The latter constituent, no doubt, finds its way into the fleece in the perspiration, just in the same way as it does into the coat of a horse. There must sometimes be fully half a pound of potash in a sheep's fleece.

With regard to milk sold off the farm, each cow giving on an average 600 gallons per year will take an

amount of minerals from the food, and indirectly from the soil, equal to 210 lbs. pure nitrate of soda, 87 lbs. superphosphate of lime (30 per cent. soluble phosphate), 19 lbs. pure sulphate of potash, and 14 lbs. ground lime. For a thousand-gallon cow the respective amounts of minerals required would be supplied by 350 lbs. nitrate of soda, 143 lbs. superphosphate of lime, 32 lbs. sulphate of potash, and 22 lbs. ground lime. The annual drain to the farm by dairy cows is therefore considerable.

When purchased foods are given to farm animals, the loss of minerals to the farm is diminished theoretically by the amount contained in the purchased foods.

VI. BODY REQUIREMENTS FROM FOOD.

There is a continual waste going on in the animal body, and it will be convenient to deal with these losses or requirements separately.

Body Temperature.—The normal temperature of farm animals is approximately 100° F. In this country the air temperature seldom comes anywhere near body temperature, and is often far below, with the result that the body is constantly losing heat, chiefly from the lungs and the external surface of the body. Experiments have shown that the loss bears a much closer relation to the exposed surface of the body than to the weight of the animal.

The rate of loss varies directly with the difference between the air temperature and body temperature, *i.e.*, the greater this difference is, the more rapidly will heat be lost from the body. The rate of loss may also be increased by work, inasmuch as some of the energy in the body is transformed into heat by increased oxida-

tion of the nutrients in the body. The heat escapes both through the lungs and the pores of the skin.

Mechanical Work or Energy.—The animal body has many functions to perform, both internal and external, in order to keep up its vitality. Internally, the process of respiration must go on, and this throws a lot of work on the diaphragm and other muscles. The heart has to be continually pumping the blood round the body. As the food passes along the alimentary track it must be masticated, digested, and largely expelled from the system; while externally the body requires to be held in position, and during walking or running has to be carried or forced through space, which involves a considerable amount of strain on the muscles. If, however, the animal is loaded, then the strain on the muscles is increased, and the animal respires more freely. All these things are a drain on the energy which is stored in the system.

Maintenance.—Ordinary wear-and-tear is constantly going on in the body, due to the strain thrown on the system in meeting the various demands, such as the production of heat and the performance of internal work. The body tissues are continually being used up, and in order to keep the animal in the same condition (*i.e.*, neither increasing nor decreasing in weight), it is necessary to give it a sufficient amount of nutrient material to maintain its body temperature, to supply energy, and repair the waste of tissue.

Production.—This refers more to the growth in size of animals, production of flesh (beef, mutton, or bacon), as well as offspring and milk. It really infers that something extra is required over ordinary maintenance. In fattening animals, it is only the food consumed in excess of the requirements for maintenance (heat,

energy, and ordinary waste of tissue) which is available for this purpose.

The various constituents of the food which are capable of supplying heat, energy, or body tissue to an animal are called "nutrients," and all the processes through which the nutrients go in the animal body in order to fulfil their respective functions are called by the word "metabolism"; such processes would therefore be called "metabolic processes."

Before attempting to describe how to meet the above body requirements, it will be necessary to give the process of digestion and the various food-stuffs that are available for feeding purposes.

VII. THE PROCESS OF DIGESTION.

Food material is taken in at the mouth of the animal and gradually passes along the alimentary or food canal, where it is attacked at different stages by various digestive juices as well as bacteria. In this way part of the food is dissolved or digested, and is therefore capable of soaking through the thin cellular walls of the intestines into the circulation, which carries this digested food to various parts of the body where the nutritive material is required.

The part of the food which resists the digestive juices travels along the alimentary track, and is finally expelled as solid excrement.

Digestion, therefore, refers to those processes through which the food passes in the animal body, by which it is dissolved and thus rendered capable of being absorbed into the blood. This solvent action is brought about by ferments or substances capable of producing fermentation.

These ferments are conveniently divided into two classes, viz., organised and unorganised; and as they play such an important part in agriculture, a general account of their action will be given.

Organised Ferments are produced by the activity of bacteria, which usually act as "oxidisers" when they attack carbohydrate substances. Common examples may be recalled, such as the souring of milk by the lactic acid bacteria, which change the milk sugar into lactic acid. Various alcoholic drinks derive their alcohol from sugar, which on fermentation with yeast yields alcohol. In the alimentary canal certain bacteria are found which attack and break down the fibrous part of food as it passes through the animal body, with the result that some of the fibre is digested.

The action of these organised ferments, which are dependent on the existence of bacteria for their formation, can only proceed to ferment food materials as long as there is a supply of air (aerobic), and moisture, as well as a suitable temperature. If air were precluded, or the food desiccated (dried) or refrigerated, this would prevent the multiplication of bacteria, and the production of these organised ferments would come to a standstill.

Certain organised ferments attack nitrogenous substances, with the production of nauseous gases. If such fermentation takes place in the animal body, as by pathogenic germs, it would cause considerable disturbance in the system.

The "Unorganised" Ferments, or enzymes, are chemical substances which, unlike the organised ferments, are not dependent on the presence of bacteria. A remarkable feature of them is that they appear to have almost an unlimited power of converting nutrient substances into a form in which they are avail-

able to plants or animals, without themselves being used up or suffering any permanent change (catalytic action). They are regarded as albuminous substances[1] which are formed from the protoplasm, and exhibit the above-mentioned "catalytic" form of action. Poisons and a too high temperature render them inactive. These ferments may be precipitated from solutions, and desiccated, but when redissolved, they continue to do their work; in fact, behave in a general way like chemical substances.

Enzymes may be classed according to their characteristic action on starch, sugar, protein, fat, cellulose, etc., and have generally a "hydrolising" effect; *i.e.*, they add the elements of water to the composition of the substance acted upon, *e.g.*, starch ($C_6H_{10}O_5$) becomes converted into sugar ($C_6H_{12}O_6$).

Enzymes are present in germinating seeds, and perform the important function of converting the starch contained in the seed into sugar, thus rendering it available for the development of the young plant. The same thing applies to tubers, bulbs, and vegetative parts generally where food material is stored.

In the animal body, ferments (enzymes) are secreted by various glands along the alimentary canal, and are largely responsible for changing food material into a form in which it can be absorbed into the circulation, as will be seen below.

The process of digestion is much the same in ruminants (*e.g.* cow) and non-ruminants (*e.g.* horse), after the food has arrived at the so-called fourth "stomach" in the case of the former, and the ordinary stomach in the case of the latter; hence the two will be dealt with separately up to this point, and collectively after.

[1] Strasburger.

VIII. MASTICATION, RUMINATION, AND DIGESTION.

Mastication.—In the case of the horse (non-ruminant), the food is taken into the mouth, where it is chewed or masticated. This has the dual effect of grinding the food down into a fine state of division so that the digestive juices may more effectively act on the food, as well as mixing it with the "alkaline" saliva which is secreted in the mouth. The saliva contains a ferment called "ptyalin," which acts on the starchy *part of the food, converting it into sugar (maltose).*

Apparently saliva is secreted in inverse ratio to the amount of water in the food. This means that, with succulent foods like grass, less saliva is secreted than would be the case with drier foods, such as hay and meals. Professor Pawlow (Russia) found with dogs that the quantity of saliva varied much more with the composition and quality of the food, than the appetite of the dog. No doubt the same thing applies to the horse.

The food is then swallowed and passes on into the stomach, but the saliva continues to act on the starchy part of the food until the latter comes in contact with the gastric juice of the stomach, which, on account of its acidity, destroys the alkaline nature of the saliva and thus prevents its action.

With ruminants the process is more complicated, due to the very large size and peculiar shape of the stomach.

Stomach of a Ruminant.—This is made up of four compartments, namely:—

(1) The paunch (rumen).
(2) The honeycomb (reticulum).
(3) The manyplies (omasum).
(4) The rennet stomach (abomasum).

In the young animal the paunch is comparatively small, but as the animal develops and begins to consume bulky foods the paunch enlarges considerably, until it becomes approximately ten times as big as the other three compartments put together.

The reticulum has a honeycomb appearance on the inside, hence the name honeycomb. It is comparatively small in size, and acts partly as a reservoir for water.

The inner surface of the omasum consists of longitudinal folds, which lie very close together in many folds or manyplies. These folds are for the purpose *of dividing the food and pressing it between* the *folds before it is passed on to the fourth stomach* (abomasum). The latter is called the rennet stomach, because the rennet used in cheesemaking is prepared by salting the stomachs of calves.

The capacity of a stomach of a full-grown ox may be 40 or 50 gallons.

The peculiar construction of the stomach as well as the habit of swallowing food unmasticated is the cause, to a large extent, of ruminants "chewing their cud," or ruminating.

Rumination.—The food is given a hurried chew and swallowed; it then passes chiefly into the paunch. Here it remains for a time, and becomes softened with the saliva which has been swallowed with the food, and in fact with any liquid that happens to find its way into this compartment. After the food has fermented a short time, it is brought back into the mouth (regurgitated), chewed a second time, and then swallowed again. The finer parts of the food pass along a groove into the third stomach, where the food is rubbed together by the manyplies before being passed on to the fourth or true digestive stomach

Here the action on the food is the same as with the horse.

This temporary sojourn of the food into the paunch gives ruminants a much greater power of digesting fibrous foods such as hay and straw than non-ruminants. The fermentation of the food in the paunch, in addition to softening it, decomposes part of the food, with the production of certain organic acids such as butyric and lactic plus carbon dioxide gas, marsh gas, and to some extent hydrogen gas. Although, there are special muscles to return the food to the mouth, they are assisted very much by these gases as they escape by the mouth into the air.

The writer has noticed tegs in winter give the food from forty to eighty chews before swallowing it a second time. Bullocks in summer often chew the food seventy to eighty times before swallowing it the second time.

The Stomach.—In the stomach the food comes in contact with the gastric juice, which contains two ferments called "pepsin" and "rennin" respectively, and in addition a certain amount of acid (hydrochloric and lactic). These acids give the characteristic acid reaction to gastric juice. It appears that "pepsin" is secreted in the first part of the stomach, and does not act on the albuminoids except in acid solutions. In acid solutions, however, the pepsin attacks the albuminoids, with the result that some of them are converted into such bodies as albumoses, peptones, and possibly amino-acids. The amino-acids at least are capable of being absorbed into the system. "Rennin" curdles milk, and is found abundantly in the stomach of calves.

The forward and backward action of the muscular

walls of the stomach is peculiar. In the first place it mixes the food thoroughly with the gastric juice, then as it forces the food forward some of it is squeezed through the round (sphincter) muscle at the far end of the stomach into the small intestines. The coarser parts are left behind till they are softened down and rendered capable of being squeezed through the round muscle into the intestines. Some absorption of soluble material takes place in the stomach, but most of it is carried on into the intestines.

Gastric juice of carnivoræ (dogs, etc.) is more acid in character than that of herbivoræ (horses, cows, etc.), which enables the former to swallow bones without harm. Professor Pawlow found that food placed directly in the stomach had little effect in stimulating secretion, but sight, smell, and taste stimulated the flow greatly even before any food had passed into the stomach. The greater eagerness the dog showed for the food, or the more appetising it was to the dog, the more abundant was the flow of gastric juice, and the richer it was in both acid and pepsin. It was also found that in character and proportion the digestive juices adapt themselves to the nature of the food.

Small Intestines.—The contents of the stomach arrive at the small intestines in a semi-liquid state and with an acid reaction. These nutrients are in various stages of digestibility. Here it is attacked by the bile and pancreatic juice, which change the food from an acid to an alkaline reaction.

The "bile," in the case of herbivoræ, is a clear, greenish-coloured liquid which is secreted by the liver, and acts on the fats partly by emulsifying them, and partly by splitting them up into fatty acids and glycerine. These fatty acids then combine with the

alkalies present in the bile to form soap. Further, bile stimulates the wave (peristaltic) action of the walls of the intestines, which is so important in carrying the food through the intestines. It also acts as an antiseptic.

The "pancreatic juice" is secreted by the pancreas, and enters the small intestines at a point close to that where the bile enters. It contains three ferments, and these act respectively on the albuminoids, fat and carbohydrates (starch), which have not been rendered soluble and diffusible by the previous ferments. These are as follows:—"Trypsin," which acts on albuminoids, forming peptones, etc.; "steapsin," which acts on fats, splitting up the fat into fatty acids and glycerine; "amylopsin," which acts on starch, changing it into sugar (glucose).

Intestinal Juices have a very similar action to the pancreatic juice. The chief ferments present are "erepsin" and "invertase." The former acts on the albuminoids which have escaped the action of the pancreatic juice, converting them into peptones, and later, according to recent research, into amino-acids; while the latter converts the malt sugar (maltose), milk sugar (lactose), etc., into grape sugar (glucose).

IX. BACTERIAL DIGESTION AND ABSORPTION.

Bacteria.—It has been mentioned above that bacteria have an important action on the food in the paunch of ruminants. This process continues in the large intestines. The large bowels of the horse are very capacious, and here the undigested food, mixed with some of the digestive juices, remains for a time. At the same time bacterial activity causes

fermentation, which decomposes to some extent the albuminoids, carbohydrates, as well as the fibrous part of the food. In this way a horse is enabled to deal with fibrous foods, such as hay and straw, in a fairly effective manner, although not quite so efficiently as ruminants.

Bacteria are comparatively rare in the stomach and small intestines, as the gastric juice and bile kill most of them off. The gases produced by fermentation in the large intestine are doubtless absorbed into the circulation and exhaled from the lungs.

Kellner points out that some bacteria have the power of forming albuminoids from amides, probably with the assistance of nitrogen-free substances (carbohydrates), and that such albuminoids can be utilised by the animal for the same purposes as the albuminoids in food. Probably this change only takes place in the case of ruminants, as bacterial activity is much greater in their case than with either horses or pigs.

Absorption of Digested Food Material. — The greater part of the digested food enters the circulation from the small intestines, which have on part of their inner surface a velvety appearance, caused by innumerable hair-like projections called ' villi." These have the power of absorbing the digested part of the food.

The absorbed nutrients find their way into the lymphatic vessels, the branches of which keep collecting up until they form ultimately two large ducts, which enter the blood by a vein in the neck. The lymphatics carry the nutrient liquid only in one direction, and act more as tributaries, pouring the absorbed nutrients into the blood at the neck vein.

The *albuminoids*, after being broken down by the digestive juices into amino-acids and other products, are absorbed by the villi, and then built up again into the complex albuminoids of the animal body.

According to Professor Henry, the *fats* previous to absorption are split up into fatty acids and glycerine. These acids combine with the alkalies of the bile to form soap. It appears that immediately after the glycerine and soap have been absorbed by the small intestines, they are reconverted into animal fats. The fats form a milky fluid with the lymph, called "chyle," which is carried into the circulation by the lymphatics.

The *carbohydrates* are absorbed chiefly in the form of glucose or similar sugars. They enter the blood and go by way of the portal vein into the liver. The sugar is then mostly removed from the blood, and stored up temporarily as glycogen, which resembles starch in composition, hence it has been designated animal starch.

Glycogen is gradually changed back to glucose as and when required. A similar power of storing up sugar is possessed by the muscles of the body.

The minerals in the food are absorbed chiefly in the small intestines, while water is absorbed in that part of the alimentary canal which lies between the stomach and the large intestine.

Destiny of Absorbed Nutrients.—The absorbed nutrients are carried along in the blood stream, where they may be utilised to maintain the body temperature, supply energy for digestion or work, repair waste of tissue, and, so far as the food is in excess of these requirements, it may be stored up as fat or flesh in the animal body. Before these various functions can be understood it will be necessary to refer to the circulation of the blood.

Circulation of the Blood.—The blood is kept in circulation by the continuous pumping of the heart. In this way the blood is forced along the arteries on its outward journey, and after the blood has passed through the various organs of the body, it returns to the heart along the veins. Whenever the blood passes through an organ in the body, *e.g.*, liver, kidneys, etc., the blood-vessel divides up into a large number of very fine blood-vessels (capillaries), which gradually come together into one large vessel as the blood leaves that organ.

The object of this subdivision of the blood-vessel into very small vessels as it passes through an organ is, first of all, to get the walls of the blood-vessels so small in the organ that nutrient liquids may pass into the blood (small intestines, and to some extent, stomach), or that impurities may be taken out (lungs, kidneys, etc.). Further, the blood may be utilised for the manufacture of digestive juices (liver, pancreas, etc.); or, in fact, some of the nutrients in it may be stored up temporarily, as in the case of glycogen in the liver.

We can now explain the functions of the various nutrients in the animal body.

X. FUNCTIONS OF FOOD NUTRIENTS IN ANIMAL BODY.

It is usual to regard the protein (crude albuminoids), fats, and carbohydrates as the chief nutrients in foods, but it will be necessary to refer to the fibre and mineral matter in addition, as they play a not unimportant part in animal nutrition. Further, the part played by water in dissolving the nutrient material, thus enabling it to be absorbed into

the circulation and carried to every part of the body, cannot be overlooked.

Carbohydrates.—The carbohydrates of the food are apparently absorbed by the small intestines into the blood in the form of sugar (dextrose). It is then carried to the liver, and the excess stored up as animal starch (glycogen) or converted into fat. The liver acts as a reserve for carbohydrate material.

The carbohydrates may also be utilised for the production of energy and heat through the carbon and hydrogen being oxidised in the blood. Modern research appears to indicate that carbohydrates may be of much greater importance as tissue-builders than has generally been supposed.

To understand how "heat" is produced in the body by the carbohydrates, one must remember that carbohydrates are composed of carbon, hydrogen, and oxygen, the last two elements always occurring in the proportion of two atoms of hydrogen to one of oxygen. The digestible carbohydrates, after finding their way into the blood, come in contact with the oxygen which is loosely held by the red blood corpuscles. This oxygen then combines with (oxidises) the carbon and hydrogen to form carbon dioxide gas (CO_2) and water (H_2O).

"Whenever chemical action takes place, heat is produced"; hence the very fact that the oxygen in the blood combines chemically with the carbohydrates, means that heat will be generated in the body and the body temperature thus maintained.

Work increases respiration, more air is taken into the lungs and more oxygen into the blood; hence more carbohydrates are oxidised, more heat is generated, and the animal gets very hot and perspires freely.

With regard to "energy," it has been found that

animals doing work require only a small amount of albuminoids, but a comparatively large amount of carbohydrates. It is therefore obvious that carbohydrates have the power of supplying energy to the animal body to meet the waste of energy that is going on during work.

Fat may also be formed from carbohydrates when they are fed in excess of the requirements for heat and energy. Kellner points out that if animals are fed with a ration poor in albuminoids and fat, but rich in carbohydrates, the animals increase in body fat at a rate which could not possibly have come from the albuminoids and fat in the food, therefore some of the fat must have been formed from the carbohydrates.

The fat of milk may be derived from the carbohydrates, for Professor Jordan (Geneva Experimental Station, New York) had a cow fed for ninety-five days on hay with maize and ground oats, which had previously been deprived of most of the fat by naphtha. The cow gained in weight, and yielded 63 lbs. of fat in the milk. The food only contained 11½ lbs. fat, of which 5·7 lbs. was digested; hence most of the remaining 57·3 lbs. fat must have been derived from the carbohydrates.

Fat.—The fat in the food supplies heat, energy, and fat to the animal body. Although it is composed of the same three elements, it has a greater value as a heat producer than carbohydrates, owing to its containing a very small proportion of oxygen in its composition (molecule), and a comparatively large amount of carbon. This means that much more oxygen will be required to oxidise the carbon and hydrogen, *i.e.*, more chemical action will take place, and as a result more heat be produced from a given weight of fat, than would be the case from an equal weight of carbohydrates.

For complete oxidation of two molecules of carbohydrate (starch) as compared with two molecules of fat (stearin) the formulæ given below will show how much oxygen would be required :—

(Carbohydrates)—

$2C_6H_{10}O_5$	+	$12O_2$	=	$12CO_2$	+	$10H_2O$
Starch	*plus*	Oxygen	*gives*	Carbon dioxide gas	*and*	Water

(Fat)—

$2C_{57}H_{110}O_6$	+	$163O_2$	=	$114CO_2$	+	$110H_2O$
Stearin	*plus*	Oxygen	*gives*	Carbon dioxide gas	*and*	Water

It is now necessary to take into account that the fat molecule is over nine times as heavy as the starch molecule, and the simplest way will be to calculate what weight of oxygen is required in each case to combine with (oxidise) 1 lb. of carbohydrate and fat respectively. Taking the atomic weights: carbon 12, hydrogen 1, and oxygen 16, we find that :—

(*a*) 324 lbs. starch require 384 lbs. oxygen for complete oxidation.

1 lb. " " $\frac{384}{324}$ lbs. " " "

1 lb. " " 1·185 lbs. " " "

(*b*) 1780 lbs. stearin require 5216 lbs. oxygen for complete oxidation.

1 lb. " " $\frac{5216}{1780}$ lbs. " "

1 lb. " "

Hence, by dividing (*a*) into (*b*) we find that stearin (fat) is 2·472 times as valuable for heat production as starch (carbohydrate). This value, however, varies with every different kind of fat, and it is usual to

take the average figure that fat is 2·3 times as valuable as carbohydrates for this purpose.

Fat, like carbohydrates, supplies "energy," or the power of doing muscular work to the animal; either internal, in digesting foods, maintaining the circulation of blood, etc.; or external, for pulling loads, etc. This can be proved by limiting the albuminoids and carbohydrates in the ration and increasing the fat; the animal is then able to do more work after the addition of fat has been made.

The fat of food may also be stored as "fat" in the animal body, although the composition of the body fat as well as the fat in milk becomes slightly changed in composition and properties from the fat of food. This is not so difficult to understand, seeing the fat is broken down in the body during digestion,[1] and immediately after absorption built up again into animal fats.

Albuminoids.—The albuminoids are the only food constituents that have the power of forming lean meat in the animal body, hence they are called "flesh-formers." They may also form the ligaments, tendons,

[1] A few years ago fat was considered to be absorbed into the blood without change, but this theory could not explain why it was that the fats of the animal body and in milk differed considerably in properties and composition from the fats of the food. The modern and more rational view is that the fats are split up by the digestive juices into fatty acids and glycerine. These fatty acids unite with the alkaline salts in the bile to form soluble soaps. The glycerine and soluble soaps are then absorbed into the circulation in the small intestines, and shortly after are reunited into animal fats, provided they are in excess of the requirements in the body for heat and force. If not, the carbon is oxidised with the oxygen in the blood to carbon dioxide (CO_2), and becomes a source of heat and energy.

hair, horns, wool, feathers—in fact all those parts of the body containing nitrogen. Further, they are absolutely necessary to sustain life.

None of the other nutrient constituents, except under certain circumstances the amides, have the power of supplying nitrogenous tissue to the body.

The albuminoids, like the fat, are temporarily split up by ferments (enzymes) during digestion and absorption into simpler bodies — albumoses, peptones, and finally, amino-acids—and these amino-acids are again built up into animal albuminoids after or during absorption into the blood. This accounts for the different character of albuminoids in the animal body as compared with those in the food from which they are derived.

When the albuminoids in food are insufficient to meet the constant waste of nitrogenous tissue in the animal body, the deficiency must be supplied from the flesh which the animal has previously stored up at the time it was receiving a liberal amount of albuminoids; the animal then begins to lose flesh. Young animals require a more liberal allowance of albuminoids than older ones, inasmuch as they have to support the constant growth in the size of the body in addition to supplying the ordinary waste of tissue.

Albuminoids may also supply heat and energy when the carbohydrates and fat are not present in sufficient quantities. In this case, the carbon and hydrogen are oxidised in the same way as carbohydrates and fat. The nitrogen, however, is not oxidised in the body, but is excreted in the urine. The albuminoids may also be converted into fat; hence we have seen that the albuminoids have the unique property of forming nitrogenous tissue (flesh) and

fat, in addition to supplying heat and energy to the animal body.

In practice, however, it is important to economise the more expensive albuminoids as much as possible, by supplying a sufficient quantity of the cheaper carbohydrates in the ration for heat, energy, and fat production, thus confining the albuminoids to the repair of waste nitrogenous tissue and the production of lean meat, etc. Kellner states that carbohydrates are quite as effective in preventing protein waste as fat.

Amides.—The amides are soluble in water, and are mostly digestible. A good example of an amide is asparagine, which is made up of the elements carbon, hydrogen, oxygen, and nitrogen. Although asparagine contains nitrogen, it has no power of adding to the nitrogenous tissue when fed to non-ruminants. With ruminants, it does appear in certain cases to have the power of economising the albuminoids. This peculiar power, according to Kellner, is no doubt brought about by the action of bacteria in the alimentary canal, and may be accounted for in two ways: by the bacteria either—

1. Converting in some way or other the amides into albuminoids; or
2. Attacking by preference the amides in the body, and thus destroying a smaller quantity of the albuminoids of food.

It would therefore appear that ruminants receiving a ration poor in albuminoids but rich in amides may utilise the amides either directly or indirectly to form flesh.

Further, it appears that amides have no power of forming fat, although when oxidised in the system

they have the power of giving heat and energy to the animal body, the nitrogen leaving the body in the urine in the form of urea.

Crude Fibre.—This is sometimes called woody fibre, and is generally present to a large extent in what are called "bulky fodders." Ruminants have considerable powers of digesting fibre, due partly to the length of time the food remains in the system, as well as to the presence and activity of considerable numbers of bacteria in the alimentary canal, which attack the fibre, thus rendering a portion of it available for nutrition purposes.

During the bacterial digestion of fibre, part of it escapes from the body in the form of gases, such as carbon dioxide gas (CO_2), marsh gas (CH_4), and hydrogen (H_2). These leave the body chiefly in the breath. Further, it appears that the energy derived from the digestible fibre is chiefly available in the form of heat, and has little value for production purposes.

The fibre in bulky foods requires a large amount of energy for mastication and digestion, and it is not difficult to understand that the previous grinding of fibrous foods by machinery into a fine state of division diminishes considerably the amount of energy required by the animal for mastication, and at the same time increases its digestibility, inasmuch as it is more easily attacked by the digestive agents. Warington points out that the undigested part of the fibre is richer in carbon than the digested.

It may therefore be taken that the chief function of the digested fibre, apart from its bulk, is to produce heat. Non-ruminants have much smaller powers of digesting fibrous foods, but the horse, on account of the large capacity of its intestines, digests it fairly well.

The pig has only a very limited power of dealing with fibrous foods.

Mineral Matter or Ash.—Lime, magnesia, and phosphoric acid are important constituents of the bony skeleton of animals; hence if the food given to animals is poor in bone-forming minerals, the supply is so small that the animal, in addition to being undersized, has bones which are diseased in some way or other (*e.g.*, rickets in pigs). Pregnant females also require more lime, etc., to supply this constituent for the bones of the fœtus. According to Prof. Henry, the animal skeleton may act as a reserve storehouse for mineral matter, and, when the supply in food is below requirements, dole out lime, phosphates, etc., in order that the various functions of the body may be maintained, *e.g.*, dairy cows may at times give more lime in the milk than is supplied in the food.

Potash is found chiefly in the muscular tissues of the body, while soda is an important constituent of blood and the digestive juices. In the stomach sodium chloride (common salt) is partly converted into hydrochloric acid, which renders the gastric juice acid. Common salt ($NaCl$) has the power of dissolving some of the albuminoids; it also improves the palatability of some foods, and increases the flow of digestive juices.

According to Kellner, the chlorine[1] as well as the soda of common salt is required for dairy cows, because, if omitted altogether, the cows gradually become weaker and may ultimately collapse, but if chloride of sodium or potash is added to the food, they quickly recover.

Vitamins.—These are accessory food substances which are found to a greater or less extent in most natural foods. Generally speaking, the ordinary

[1] Further research appears to show that iodine may play an important part in maintaining the health of animals.

methods of chemical analysis have failed to reveal their presence, with the possible exception of a colour test for fat-soluble A vitamin.[1] Their presence is revealed by carefully regulated experiments to test their effect on living animals, *e.g.*, rats, mice, guinea-pigs, and even farm animals, and in this way, at least four[2] vitamins are recognised, viz. :—

1. *Fat-Soluble A Vitamin.*—This is found in association with animal fats; but is apparently absent, more or less, from oils obtained from oil seeds under present methods of oil extraction. Vitamin A can be stored in the animal body and passed on to the offspring. Capt. Golding points out that it can be destroyed by heating for say twenty-four hours at 120° F. in presence of air; but the saponification of oil, in absence of air, does not destroy it.

Vitamin A is found in the following food-stuffs, and may be grouped as follows :—

(1) *Rich*: cod-liver oil, butter, and cream (made from milk of cows having ample pasture).
(2) *Fairly Rich*: new milk, fish oil, fresh cabbages, lettuce, maize germ, fresh eggs, etc.
(3) *Present in Small Quantity*: wheat (grain), maize (grain), soya beans, fresh carrots, and raw potatoes.

[1] J. A. Drummond and A. F. Watson found that cod-liver oil dissolved in chloroform or carbon bisulphide, and shaken up with a drop of sulphuric acid, gives a violet-red coloration, and the intensity of the colour appears to vary with the richness of the oil in vitamin A, *i.e.*, the richer the oil in vitamin A, the more intense the colour (analyst).

[2] There is a tendency to divide fat-soluble vitamin A into two, viz. :—(1) Fat-soluble A which is essential to growth; (2) Fat-soluble D (anti-rachitic) the absence of which in a diet gives rise to rachitic symptoms. With this division, there are five vitamins.

Vitamin A is supposed to be directly concerned in the development of the bone, etc., and its absence may be one cause of rickets.

2. *Water-Soluble B Vitamin, or the Antineuritic Vitamin.*—This vitamin is soluble in water, but apparently not in fats. Unlike vitamin A, it is not capable of being stored up in the animal body, and a regular supply is necessary. When vitamin B is not supplied in the food, one effect is, that the animal suffers from paralysis of the limbs (*e.g.*, cramp in pigs). In fact, the disease known as beri-beri in eastern countries where polished rice formed the staple food of the human population, was successfully treated by infusions of the rice husks that had been removed in the polishing process.

Vitamin B is found in the following food-stuffs:—

(1) *Rich*: dried yeast, extracted yeast, wheat germ, maize germ, green leguminous and cereal crops, fresh eggs.
(2) *Fairly Rich*: wheat bran, peas (grain), soya beans.
(3) *Present in Small Quantity*: new milk, wheat (grain), maize (grain), fresh cabbages, carrots, lettuce, raw potatoes.

Vitamin B is not so easily destroyed by heat as vitamins A and C.

3. *Vitamin C, or Antiscorbutic Vitamin.*—The absence of this vitamin in the food causes the disease called scurvy. It is easily destroyed by heating. It is found chiefly in succulent fruits (lemons, oranges, etc.), green vegetables, succulent roots (swedes, turnips, kohl-rabi), and new milk.

4. *Vitamin E.*—In the *American Journal of Science*, Professor H. M. Evans and Mr K. Scott Bishop (University of California)

fed animals on artificial diets of "purified" proteins, fats, and carbohydrates, with the necessary salts, and adequate doses of vitamins A, B, and C. As the factors for growth and for resisting scurvy were present, young animals were successfully reared to maturity. But a large proportion were sterile, and practically all were sterile in the second generation. However, when fresh green leaves of lettuce[1] formed part of the ration, a comparative sudden restoration of fertility resulted. Further, the sterile condition did not arise, even when other vitamins were restricted to such an extent that growth was not normal. The experimenters conclude that natural green food-stuffs contain a factor or substance, "vitamin E," which prevents sterility arising from artificial diets. Sterility appears to be common in stock reared on artificial or preserved foods, and in menagerie animals fed on unaccustomed diets.

Whether vitamin E is a new vitamin or a peculiar combination of vitamins A, B, and C, is a matter which must be accepted with reserve, until much more experimental work has been carried out on the subject. It will be noted, however, that lettuce leaves contain vitamins A, B, and C.

These mysterious somethings called vitamins[2] are apparently formed by green plants, and it is from this source that farm animals receive their supply. In the case of fish meal, cod-liver oil, etc., the vitamins have been derived from the sea (green) flora by fishes and, so far as vitamin A is concerned, supplied to farm animals in these well-known products.

The discovery of vitamins has thrown some light on the hitherto inexplicable superiority of certain feeding stuffs, etc., *e.g.*—

(1) Why new milk is the best food for calves.

(2) Why "bran and oats," fish meal, etc., grow young stock so well.

[1] Further research has shown that vitamin E is also present in wheat-germ oil, oats, maize, and lucerne.

[2] Many of the foods claimed to be rich in vitamins are also rich in minerals, and the good effects, in some cases, may be due to the minerals supplied.

(3) Why good grass or green forage crops generally are so excellent for milk production.
(4) Why swedes are better for milk production than mangels.
(5) Why green food or cod-liver oil has an almost magical effect on ailing animals.
(6) Why natural home-grown grains are often preferable to steamed and cooked artificial feeding stuffs, or even kiln-dried grain.
(7) Why expressed oil-cakes are preferable to chemically extracted oil-cakes; especially when one remembers that certain fat or oil solvents remove the vitamins as well. It seems pretty obvious that the fat-soluble A would be removed in this way.
(8) Why certain mares, cows, etc., do not settle down to breeding until they are turned out to grass.
(9) Why the most successful breeders of farm live stock keep their breeding animals, as far as possible, under natural conditions.

Water.—Water is indispensable in the animal body, for without water there can be no life, seeing that it is an essential constituent of the living matter (protoplasm). All common foods contain a certain amount of water, which assists the animal in chewing the food. When the food is too dry, it is necessary for the animal to drink water occasionally to facilitate absorption of the digested food into the blood, and the ejection of waste substances from the body.

Water is a wonderful regulator of the body temperature, because, when the body is abnormally hot, a large amount of this heat is absorbed in converting the water into water-vapour. The water-vapour then leaves the

body by the lungs in the process of respiration, as well as by perspiration through the pores of the skin. On the other hand, an animal drinking water at too low a temperature may chill the body so severely as to cause colic, etc. This would apply more especially to work horses.

Bulky fodders and foods rich in albuminoids cause animals to drink considerable quantities of water, and as the water required depends on so many factors, it is wise to let the animal determine the quantity required for itself. It is generally safe to allow farm animals to drink water at atmospheric temperature.

Kellner found that for each 100 lbs. of water drunk and supplied in the food to a stall-fed ox, 46·3 per cent. appeared in the solid excrement, 29·2 per cent. in the urine, and 24·5 per cent. in the breath and perspiration.

XI. COMPENSATING NUTRIENT MATERIAL,[1] ETC.

Nature has supplied the animal body with a wonderful power of meeting emergencies. It often happens that an animal is not receiving sufficient food for immediate requirements. Well, how is this difficulty overcome by the animal body? We have already seen that when animals are fed in excess of requirements for keeping up the body heat and meeting the demand for energy and tissue waste, that the excess is utilised for the formation of fat and flesh. This excess nutrient material must be carried in a more or less liquid state to the point where it is actually laid down as fat or flesh; therefore, at any given time, it is reasonable to expect that there will be present in the animal body a certain, if not considerable, amount of this "floating" nutrient material.

[1] This metaphor has been taken from the compensating balance wheel of a watch, which adjusts itself automatically to variations of temperature.

During starvation it would appear that the various functions of the body are maintained, and in order to do this the animal draws on the reserve which it has stored up, first on the "floating" nutrient material, then on the fat, and finally on the flesh.

Kellner has shown that when an animal is deprived of albuminoids in the ration, that nitrogen continues to appear in the urine. The nitrogen excretion diminishes rapidly at first after nitrogen is withheld, due, it is believed, to the loss falling on the floating nitrogenous nutrient material in the first instance. It appears that energy may be stored up in the muscles, even minerals may be placed in reserve in the bones, and both drawn on when necessity arises.

These wonderful compensating forces, or this power of storing reserves, explains why it is that a milking cow will continue for a time to yield average milk, even when the ration is insufficient; but if carried beyond a certain point, the cow will lose flesh, or, in farming language, "milk herself thin."

Respiration.—The blood is continually circulating through the lungs, and as it enters is of a dark colour, due to the carbon dioxide gas it contains. On its passage through the lungs by way of the very fine blood-vessels (capillaries), it comes in contact with the air that has been drawn into the air cavities of the lungs. Here the blood takes up the oxygen in the air, and liberates the carbon dioxide gas due to the red colouring matter (hæmoglobin), having a much stronger affinity for oxygen than carbon dioxide gas. The blood then changes to a bright scarlet colour and the carbon dioxide gas escapes from the lungs in the breath, along with considerable quantities of water-vapour. In this way the lungs are continually ridding the blood of this

injurious product of oxidation. At the same time the blood is being charged with oxygen, which it carries round the body, giving it up wherever it is required to oxidise the food for the production of heat or work, etc.

Excretion.—The chief impurities of the blood which are not removed by the lungs are urea, certain salts, and water. Urea is formed from the decomposition of nitrogenous matter in the blood. The carbon and hydrogen alone are oxidised to carbon dioxide and water respectively. The nitrogen, however, forms urea, and is removed by the kidneys as well as through the pores of the skin (perspiration).

When the urine is collected, and the amount of nitrogen in it determined, one can tell by difference from the total food digested, the amount of albuminoids which have been stored in the body. The difference between the compositions of food and solid excrement gives the amount digested by the animal.

The various salts contained in the food which are not required by the body are got rid of in the urine, and to some extent in the perspiration. Soda and potash are common bases in these salts, because they are fairly abundant in the food given to farm animals, and produce salts which are easily dissolved.

The undigested food is expelled from the body in the form of solid excrement. Seeing that the food canal of ruminants is from twenty to thirty times the length of the body, while in horses and pigs it is from ten to fifteen times, the food naturally remains in the alimentary canal some time before the undigested part is finally expelled. With pigs and horses this period may be about two days, while with ruminants four to six days may be required.

XII. FOODS AND FEEDING STUFFS.

Feeding stuffs may be divided into those which are comparatively rich in one or more of the three most valued nutrients—viz., albuminoids,[1] fats, and carbohydrates (concentrates), and those feeding stuffs which are comparatively poor in the above-mentioned nutrients (bulky foods).

The *former* are represented by the various oil-cakes, pulse grains (peas and beans), cereal grains (wheat, rye, barley, oats, maize, and rice), including by-products from flour mills, breweries, distilleries, etc.; while the *latter* includes grass, clover hay, seeds and meadow hay, straw from cereals, roots, etc. Bulky fodders (hay and straw) are very rich in fibre, while root crops are generally low in this constituent.

The concentrates may be subdivided into groups according to their richness in one or more of the three most valued nutrients: *e.g.*, oil-cakes, peas, beans, soya beans, etc., are all rich in albuminoids; flax seed, cotton seed, soya beans, and rape seed are rich in oil; while wheat, barley, oats, maize, and rice are exceedingly rich in carbohydrates. Very often we find that foods rich in oil are also rich in albuminoids; *e.g.*, linseed and decorticated cotton cakes. The undecorticated cotton cakes, brewers' grains, etc., although fairly rich in albuminoids and oil, possess a considerable percentage of fibre, which decreases their value to some extent for fattening purposes. In this mode of subdivision, interesting points are revealed with regard to the seeds from different natural orders of

[1] As the protein in concentrates consists largely of albuminoids, the common term "albuminoids" will be employed in dealing with concentrates.

Composition and Nutritive Values of Various Farm Foods of Average Quality.

Compiled by Dr CHARLES CROWTHER, The University, Leeds, with additions by the Author.

FOOD.	FOOD INGREDIENTS: Total Percentage in Food. Total Dry Matter.	Total Percentage in Food. Crude Protein (Albuminoid).	Total Percentage in Food. Oil.	Total Percentage in Food. Soluble Carbohydrate.	Total Percentage in Food. Crude Fibre.	Digestible Percentage in Food. True Protein (Albuminoid).	Digestible Percentage in Food. Oil.	Digestible Percentage in Food. Carbohydrate and Fibre.	Albuminoid Ratio in Digestible Matter.	Proportion of "Full Value," viz. 100.	Starch value, i.e. Weights of Starch Equivalent, for Fattening Purposes, to 100 lbs. of the Food of the Composition given (Kellner).
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.			lbs.
Cotton-seed Cake—											
Decorticated . . .	92	41	9	26	8	34	8½	20	1 : 1¼	97	71
Undecort. Egyptian .	88	22	5½	34	20	15½	5¼	20	1 : 2	84	40
Undecort. Bombay . .	88	20	4½	35	22	14	4	21	1 : 2¼	84	37
Linseed Cake . . .	88	30	10	34	9	25	9½	32	1 : 2¼	97	76
Rape Cake . . .	90	32	10	29	11	22	8	24	1 : 2	95	61
Earth-nut Cake—											
Decorticated . . .	89	46	10	23	5	40	9½	20	1 : 1¼	98	79
Cocoa-nut Cake . . .	89	22	10	36	15	17	9½	39	1 : 3¾	100	78
Palm-nut Cake . . .	90	17	10	36	22	14	9½	36	1 : 4	100	72
Soya Bean Cake (Soya Cake)	88	43	6	28	4	34	5½	22	1 : 1	100	67
Soya Beans . . .	89	36	17	26	5	28½	15½	20	1 : 2	98	82

Linseed	91	23	36	23	6	17	34	21	1 : 5½	99	119
Locust Beans . . .	86	6	1½	70	6	3½	1	70	1 : 20	97	73
Yeast residue, extracted .	88	49	3	30	...	40½	1	24	1 : 0·6	100	65
Fish Meal (low in Oil) .	87	52	2	...	...	43½	1½	...	1 : 3	100	44
Gram (Indian Pea) . .	89	23	1	54	5	14¾	2¾	50	1 : 3	97	71
Wheat Middlings (Fine Pollards) . . .	88	15	3½	62	5	12	3	56	1 : 5¼	100	74
Wheat Sharps (Coarse do.)	88	15	4½	57	8	11	3½	50	1 : 5¼	85	58
Wheat Bran . . .	87	14	4	56	9	10	3	45	1 : 5¼	78	47
Oatmeal	90	15	8	60	3	10	7	48	1 : 6½	100	72
Gluten Meal . . .	90	38	4	45	2	33	3½	42	1 : 1½	96	77
Gluten Feed . . .	90	26	3	53	6	21	2½	52	1 : 2⅞	96	74
Rice Meal	90	12	12	50	8	6	10	42	1 : 11	100	70
Malt	92	10	2½	68	8	6	2	63	1 : 11¼	96	70
Malt Dust or Coombs .	90	23½	2	44	12½	11½	1½	39	1 : 3¾	75	40
Brewer's Grains (Wet) .	24	5	1½	12	5	3½	1¼	10	1 : 3¾	86	15
Brewer's Grains (Dried) .	91	19	5½	45	19	12½	5	38	1 : 3¾	84	51
Molasses, or Treacle . .	78	10	...	60	...	...	...	55	...	87	48
Meat Meal	89	72	13	...	...	67	12½	...	1 : ½	100	94
Beet Slices (Fresh) . .	7	½	...	4¾	1½	¼	...	5	1 : 20	94	5
Beet Slices (Dry) . .	89	8	½	58½	17½	3½	...	63	1 : 18	78	52
Wheat	87	12	2	69	2	9	1¼	65	1 : 7½	97	73
Barley	86	10	2	67	5	7	1¾	64	1 : 9¾	98	74
Oats	87	12	6	55	10	9	5¼	45	1 : 6½	95	63
Rye	87	11½	2	70	2	9	1	65	1 : 7½	95	72
Maize	89	10½	5	70	2	7	4½	68	1 : 11¼	100	84

Composition and Nutritive Values of Various Farm Foods—*continued.*

FOOD.	FOOD INGREDIENTS. Total Percentage in Food. Total Dry Matter.	Crude Protein (Albuminoid).	Oil.	Soluble Carbo-hydrate.	Crude Fibre.	Digestible Percentage in Food. True Protein (Albuminoid).	Oil.	Carbo-hydrate and Fibre.	Albuminoid Ratio in Digestible Matter.	Proportion of "Full Value," viz. 100.	Starch Value, *i.e.* Weights of Starch Equivalent, for Fattening Purposes, to 100 lbs. of the Food of the Composition given (Kellner).
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.			lbs.
Beans	86	25	1½	48	7	10	1¼	48	1 : 2¾	97	67
Peas	86	23	1½	54	6	17	1	53	1 : 3¼	98	70
Straw—Wheat	86	3	1¼	37	40	¼	½	34	1 : 71	32	12
Barley	86	3½	1½	38	38	½	½	40	1 : 83	46	19
Oat	86	3½	2	38	37	1	½	39	1 : 40	43	19
Rye	86	3	1¼	33	44	½	½	35	1 : 73	30	11
Bean	82	8	1	31	36	3¼	½	36	1 : 11½	48	19
Pea	86	9	1½	34	35	3½	¾	32	1 : 9¾	44	15
Meadow Hay	86	10	2½	42	26	4	1	41	1 : 11	74	31
Clover Hay	84	13	2½	37	25	5½	1½	38	1 : 7½	74	31
Pasture Grass	20	3	¾	10	5	1½	½	11	1 : 8¼	92	12
Clover (Green)	19	3½	¾	8	5	2	½	9	1 : 5¼	86	10

Vetches (Green) . .	16	3½	½	6	5	2	¼	7	1 : 4	83	8
Lucerne (Green) . .	24	4½	¾	9	7	2	½	9	1 : 5¼	79	10
Sainfoin (Green) . .	20	3½	½	8	5½	2	½	8½	1 : 5	85	10
Buckwheat (Green) . .	16	2½	½	7¾	4¼	1	¼	7¾	1 : 8½	87	8
Maize (Green) . . .	17	1½	½	9	5	¼	¼	8	1 : 34	82	7
Cabbage	15	2½	¼	7	2	1½	½	7	1 : 5½	94	9
Rape	14	2¾	¾	6	3	1½	½	6	1 : 5	75	8
Turnip Tops . . .	12	2	½	5	2	½	¼	5	1 : 11½	93	6
Turnips	9½	1	¼	6	1	¼	$\frac{1}{10}$	6	1 : 25	77	6
Swedes	11½	1¼	¼	8	1½	¼	$\frac{1}{10}$	8	1 : 33	85	7
Mangels	12	1¼	¼	9	1	$\frac{1}{10}$	$\frac{1}{10}$	9	1 : 92	72	7
Carrots	13	1¼	¼	9½	1½	½	$\frac{1}{10}$	10	1 : 21	87	9
Sugar Beet . . .	25	1¼	¼	20	2	¼	$\frac{1}{10}$	20	1 : 81	75	15
Potatoes	25	2	¼	21	1	$\frac{1}{10}$	$\frac{1}{10}$	19	1 : 192	100	19
Silage (Red Clover) . .	30	5½	2	11½	8½	2	1	11½	...	77	12
Apple Pomace (Fresh) .	20	1	¾	13	4½	¼	¼	9½	1 : 40	92	9
Apple Pomace (Dried) .	90	4	3	59	20½	1¼	1½	42½	1 : 37	78	36
Spent Hops . . .	89	15	6¾	40	21	3	4	22½	1 : 10¾	83	28
Milk—Cow (Whole) .	12½	3½	3¾	4¾	...	3¼	3¾	4¾	1 : 4¼	100	16
Cow (Skim) . .	9½	3½	¾	4½	...	3¼	¾	4½	1 : 2	100	9
Cow (Separated)	9	3¾	$\frac{1}{10}$	5	...	3½	$\frac{1}{10}$	5	1 : 1½	100	8
Ewe	20	6½	8	5	...	6	8	5	1 : 4	100	29
Mare	9	2	1¼	5¾	...	1¾	1¼	5¾	1 : 5	100	10
Whey	7	1	¼	5	...	...	¼	5	1 : 5½	100	6
Buttermilk	10	4	1	4	...	3¾	1	4	1 : 1¾	100	9

plants; *e.g.*, leguminous seeds (pulse grains) are rich *in albuminoids and poor in oil. Cereal grains are exceedingly rich in carbohydrates.* *(See Table, pp.* 48-51.)

With these general remarks we will now proceed to examine the various foods and feeding stuffs in greater detail.

(a) Concentrates Rich in Oil.

Flax Seed, or Linseed.—This is the seed of the flax plant (*Linum usitatissimum*), and is grown chiefly in Canada, South America (River Plate), Russia, and India (Calcutta) for its seed, which is extremely rich in oil (37 per cent.) and fairly rich in albuminoids (20 per cent.). The composition, however, varies according to the climate in which it is produced; *e.g.*, warmer climates like India appear to produce seeds with a higher percentage of oil, while in colder climates (America) the oil content is somewhat less. Russian seed is apt to contain rape or other weed seeds. In Ireland the plant has been grown largely for its fibre, but it is the seed which most concerns us at present.

Approximately half a million tons of flax seed are imported into this country annually, primarily for the extraction of linseed oil, which is used so largely for the manufacture of linoleum, and paint, for drenching cattle, or for feeding with chaff and meals to horses as a laxative. It has also the effect of enabling horses, etc., to cast their coats in late winter or spring much more readily.

Linseed meal is produced by grinding flax seed, and is a favourite food for young calves which are having a part of their milk ration substituted by meals. It has a composition rather similar to that of milk,

is very digestible, and is probably the safest milk substitute that can be used for young calves. The seeds should be ground in such a way as to bruise the husk with the minimum amount of crushing of the kernel, otherwise oil will be lost in the grinding. The bushel weight of good flax seed is 52 to 56 lbs.

Oil Extraction.—The seed is first of all screened to remove impurities, and in many cases is led past powerful magnets, which remove any pieces of metal that may have found their way into the seed. It is then ground to a meal with steel rollers, and conveyed to a receptacle or kettle, where it is heated to about 160° F. with steam. This makes the oil thinner and facilitates its extraction. The heated meal is admitted into a movable, bottomless iron box, which is slided forward and backward over a shallow rectangular mould, beneath which is placed a long piece of sacking which is a little wider than the cake. One forward and backward sweep of the box fills the mould with meal. A low pressure is applied to bring the meal together into the cake form, so that, after the ends of this narrow piece of sacking have been turned over the cake, it is completely surrounded and can be transferred to the oil press, where there are, as a rule, four tiers of cakes to each mould, so as to admit of one tier being filled and the other three being left in the press at varying stages of oil expression.

For cakes with 8 per cent. of oil, it takes approximately five minutes to fill a tier of cakes ready for pressing, then five minutes under low pressure and thirty minutes under high pressure (2 tons per square inch) will complete the oil extraction. The cakes are now taken out, their rough edges trimmed by machinery, and after being cooled are ready for sale.

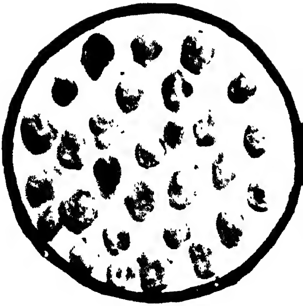
When 12 per cent. oil is left in the cakes, the time under low pressure is extended and that under high pressure reduced. If, however, 16 per cent. oil is *required in the cake, the oil may be extracted entirely under low pressure. A slightly lower temperature* may also be employed in the kettle for the meal before expression.

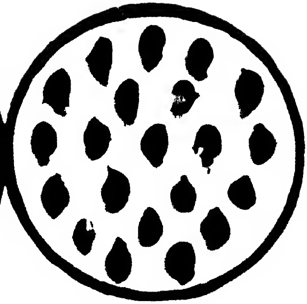
The cakes vary slightly in weight, but will run about 190 cakes to the ton; *i.e.*, 12 lbs. each.

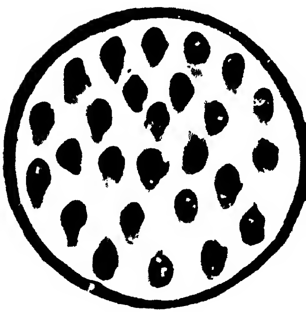
Cotton Seed.—This is grown chiefly in the tropics —viz., Egypt, India (Bombay), United States, South America (Brazil), Salonica, etc.—and consists of the seed of the cotton plant (Gossypium). The seeds have a considerable amount of cotton attached, which is doubtless intended by nature to aid their distribution by wind. It is usual for the cotton-grower, after collecting the seed, to send it to the ginning factory, where the cotton lint is removed. It is then found that the seed has a hard, brownish husk, with a whitish or greyish kernel which is exceedingly rich in oil. The percentage, however, varies according to the country of origin. Egyptian seed may contain about 24 per cent. oil, while the oil in American seed may be about 20 per cent., Bombay less still (17 per cent.).

The seeds also differ in external appearance; *e.g.*, Brazilian is probably the largest seed and can be obtained practically free from cotton lint. Egyptian seed is comparatively large, with very little cotton lint adhering to the narrow end of the seed. Salonica seed is somewhat smaller, but some of the seeds are covered with cotton lint, which prevents one seeing the colour of the husk. Bombay seed is a comparatively small seed, and the seeds are completely covered with cotton lint, with the result that they look like small balls of cotton.

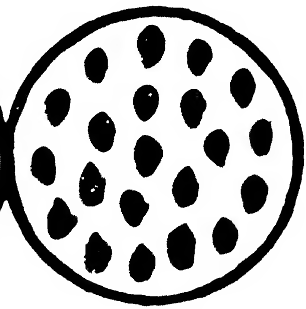
PLATE II.







Salonica



In America, and to some extent in this country, solvents such as naphtha, benzene, etc., are used to extract the oil instead of pressure, with the result that a larger amount of oil is extracted. In some cases both solvents and pressure may be used. The residual cake contains a smaller percentage of oil, but a correspondingly higher percentage of albuminoids. Generally speaking, the poorer a cake is in oil, the harder it will be.

The extracted oil is of a pale yellowish colour, and possesses a pleasant flavour. At present it is largely used for the manufacture of soap, lubricating oils, and in one or two cases as a cream substitute for calves. It differs from linseed oil in being a "non-drying" oil. During this process of oil extraction the leathery husk may be screened out, when the residue cake obtained is decorticated or "dehusked" cotton cake, as in the case of American seed. The Bombay and often the Egyptian seed, are not usually decorticated, hence the resulting cake residue is called undecorticated.

The process of oil extraction is very similar to that employed for linseed, but the meal in the kettle requires to be heated to a higher temperature, to facilitate the extraction of oil. Further, the hulls of cotton seeds are very hard and indigestible, consequently they require a second grinding before the hulls are sufficiently fine for feeding purposes. This second grinding is done by a pair of very heavy millstones, placed in a vertical position so as to concentrate the weight on a small part of the rim. These stones then revolve round a central pivot in a circular trough. The advantage of stones revolving horizontally and vertically at the same time is, that they grind as well as roll or crush the seed.

The cakes are slightly heavier than linseed cakes,

and run about 160 to the ton with Egyptian cakes containing 5 per cent. oil, and 150 in Bombay cakes containing 4½ per cent. oil.

Soya Beans.—The leguminous plant called soya bean (*Glycine hispida*) is largely grown in Manchuria, Northern China, Japan, America, etc., and produces seeds in pods about the size of an ordinary pea. The colour of these seeds is generally yellow. They contain 16 to 20 per cent. of oil, and on this account are not largely fed to stock without having a part of the oil extracted. If the pure seed is fed to stock, it should be mixed with foods which are rich in carbohydrates, such as maize or other cereal grains, and only up to the extent of one quarter of the concentrates given.

These seeds are also rich in albuminoids (36 per cent.). The nutrients are very digestible.

Hemp Seed (*Cannabis sativa*).—This is a small whitish seed, very rich in oil (33 per cent.), moderately rich in albuminoids (16 per cent.), poor in carbohydrates (1½ per cent.), and very low in fibre (2 per cent.). The nutrients are also very digestible. The residue after the oil has been expressed should only be fed to cattle, and even then in small quantities at a time.

Ground-nut, or Pea-nut (*Arachis hypogæa*).—The ground-nut is grown largely in North America. It is also called earth-nut and monkey-nut. The plant is remarkable for the fact that after fertilisation of the flower, the flower-stalk pushes the fruit into the ground, where it ripens. The fruit consists of a sausage-shaped, straw-coloured husk or pod about an inch long, with two seeds or pea-nuts enclosed. These pea-nuts are rich in oil (41 per cent.), and on this account are utilised as a source of oil.

Sunflower Seed (*Helianthus annuus*).—The sunflower seed is largely imported from Russia, and contains approximately 30 per cent. oil; hence the oil is often extracted. The seed is sometimes fed to poultry.

Rape Seed.—This is the seed from rape, and comes chiefly from Russia, Germany, Austria Hungary, and East India, where it is grown on account of its richness in oil.

The seed contains 35 to 45 per cent. oil. It is apt to contain mustard seed, which may cause harm to live stock if present in quantity. It may also contain considerable quantities of sand.

The expressed oil is used very largely for lubricating machinery, and the residual cake is rape cake.

Kapok Seeds.—These seeds are obtained from a tropical plant called *Eriodendron anfractuosum*, which is related to the cotton plant. It is largely grown in Java, Sumatra, and the Philippine Islands, and to a small extent in India, Ceylon, and Central America.

The seeds contain 24 to 26 per cent. oil, 22 to 24 per cent. albuminoids, and 20 to 22 per cent. fibre. They are peculiarly-shaped seeds, dark in colour, and approximately the size of vetches. The narrow end of the seed is formed by a piece of husk being apparently superimposed on the husk which is adjacent to the kernel, forming a kind of blister, and this part of the husk can be easily removed without exposing the kernel. The husk is thick, horny, and indigestible.

Palm-nut Kernels are also very rich in oil (49 per cent.), moderately rich in carbohydrates (27 per cent.), with only a low percentage of albuminoids (8 per cent.). The nutrients are very digestible. The residue is called palm-nut cake.

• **Cocoa-nut Kernels.**—Very similar to palm-nut; residue forms cocoa-nut cake.

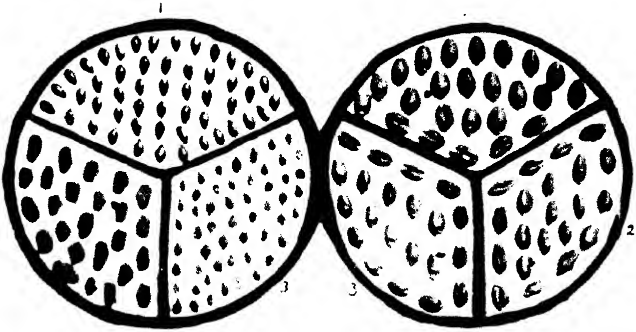
(*b*) Oil-cakes—Low in Fibre.

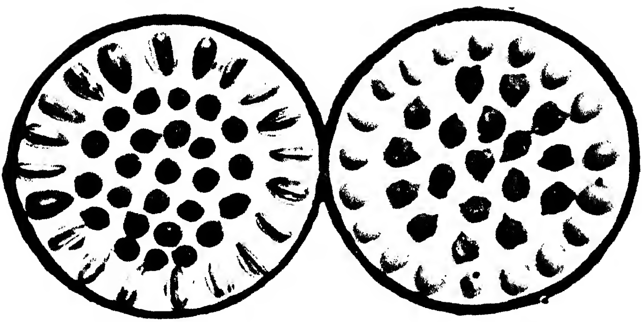
The oil-cakes are residues which are obtained chiefly from the various oil seeds after they have been ground to a meal, cooked, and subjected to pressure or treatment by solvents in order to extract the major part of the oil. The name of the cake is derived from the particular kind of seed used in its manufacture; *e.g.*, linseed cake, cotton-seed cake, cocoa-nut cake, etc.

These oil-cakes are, from a feeding point of view, still very rich in oil. In fact, speaking generally, those cakes with more than 12 per cent. of oil are apt to be too laxative for cattle if 4 lbs. per head per day is exceeded. Oil-cakes are at the same time very rich in albuminoids, and exceedingly valuable for blending with bulky fodders (hay and straw), which are generally poor in both oil and albuminoids, the effect being to raise the character of the whole diet.

The quality generally depends on the country of origin of the seed, its purity, and the manner in which the oil has been extracted. Good oil-cakes should be made from sound seed that has been well screened to remove any sand. The cakes should be at least 95 per cent. pure, and should not contain more than 2 per cent. sand. At the same time the cakes should be free from impurities that are injurious to stock. Further, it is most important that the cakes should be free from mouldiness, otherwise digestive troubles may arise when they are fed to stock.

The manure made from animals fed on oil-cakes is very rich in nitrogen and other manurial constituents,





Sunflower Seed, outside.
Kapok Seed, inside (p. 57).

Soya Beans, outside (p. 5[illegible]).
Indian Pea, inside (p. 68).

Various Seeds.

[To face p.

consequently in ascertaining the full value of these cakes, credit must be given for the manurial residue.

These cakes are ground down to a meal when requested by the purchaser, and receive the name of ground linseed cake, decorticated cotton-cake meal (yellow meal), etc.

The analyses given below are average figures, but in practice cakes may often be obtained giving a higher or a lower analysis. The words "about" and "approximate" are not written with every analysis, as it is quite unnecessary when this is understood by the reader.

Linseed Cakes are greyish brown in colour. The three chief kinds on the market are: English, American, and Russian.

The "English" cakes can now be obtained from 95 to 98 per cent. pure, and with 8 to 16 per cent. of oil. Generally speaking, cakes rich in oil are fairly soft in texture, while those low in oil are comparatively hard. Three typical analyses would be:—

(*a*)	Oil,	8	per cent.;	albuminoids,	28	per cent.
(*b*)	„	12	„	„	26	„
(*c*)	„	16	„	„	24	„

"American" cakes are poor in oil (less than 8 per cent.), and inclined to be hard. They are somewhat richer in albuminoids than home-made cakes.

The "Russian" cakes are often rich in oil, and may contain 12 per cent. or more. At the same time they are liable to contain weed seeds and other impurities.

Linseed cakes are also fairly rich in carbohydrates (28 per cent.), and generally low in fibre (8 per cent.). When the cake is ground into a meal it is called "ground linseed cake."

It is probably the most digestible and most valuable of the oil-cakes for feeding purposes, seeing it can be fed to very young calves and lambs without danger.

For fattening cattle it stands unrivalled in giving the desired "bloom" or "finish" and touch. It gives a slightly softer fat, which in cattle and sheep is an advantage; with pigs, however, this is a disadvantage.

When fed to dairy cattle it should only form a small proportion of the concentrated foods, otherwise the butter is soft and it very soon becomes rancid.

The laxative effect of linseed cake makes it especially valuable for blending with foods of the oppositive tendency. It is probably the most expensive concentrate per "food unit" (see also p. 137).

A good sample of linseed cake should possess the following characters:—

(*a*) Nice fresh greyish brown colour; free from mouldiness externally or any musty smell.

(*b*) When crushed between the teeth, it should be free from grittiness or any bitter flavour.

(*c*) The surface and freshly broken edge of the cake should be examined to see if the "husks" or "hulls" of any foreign seeds are visible, *e.g.*, polygonum, corncockle, or spurrey.

(*d*) When ground linseed cake is made into a gruel with 1 gallon boiling water to 2 lbs. meal, it should swell up into a thick jelly. If oil has been extracted with solvents, the meal may not swell up into a jelly at all.

Decorticated Cotton Cake is bright yellow in colour. It is usually made from American cotton seed, and has the hulls removed before the oil is extracted from the kernel; hence the cake has only traces of "hulls"

present, and is called "decorticated" (dehusked) cotton cake. The removal of the black hulls gives the cake the nice yellow colour of the kernel.

This cake is exceedingly rich in albuminoids (41 per cent.). The oil may vary from 7 to 14 per cent., but 8 per cent. is the most usual. It is moderately rich in carbohydrates (26 per cent.) and low in fibre (8 per cent.).

Occasionally hard lumps or "knots" are found in the cakes, especially those low in oil, due to the meal collecting into balls while it is being steamed in the kettle; the subsequent pressure makes them into small hard balls or "knots." Such cakes should be avoided. When the cake is ground into a meal, the so-called "yellow meal" is obtained.

This cake is far too rich in albuminoids to be fed alone, and should generally be blended with other concentrates which are poor in oil and albuminoids, but exceptionally rich in carbohydrates such as maize, barley meal, etc. It can be used for fattening bullocks up to 4 lbs. per head per day, as part of the concentrate ration, or for dairy cows, seeing it improves the firmness and keeping qualities of the butter, although the butter may be slightly pale in colour.

It should be fed very carefully, if at all, to young cattle or pigs, as it may form into balls in the stomach and cause harm.

The manure resulting from the feeding of this cake is very valuable (see pp. 142 to 144).

When purchasing decorticated cotton cakes, one should generally avoid cakes with only 5 to 6 per cent. oil (usual 8 to 10 per cent.), as well as those which contain large amounts of fibre, say 16 to 20 per cent. (usual, 8 per cent.).

Ground-nut or Earth-nut Cakes are rather coarse in texture and greyish brown in colour, coming about halfway between the colour of Egyptian cotton cake and that of linseed cake. The cake has a pleasant taste, and stock like it.

The whole nut (pod and seeds) may be ground up and made into cakes, when one gets "undecorticated ground-nut cake," but the cake used in this country is usually made from the seeds or nuts after the pod has been removed, and is called "decorticated ground-nut cake."

The "decorticated" cake is very rich in albuminoids, as the following analysis shows:—Albuminoids, 46 per cent.; oil, 10 per cent.; carbohydrates, 23 per cent.; fibre, 5 per cent. The composition is very similar to that of decorticated cotton cake, but slightly more digestible, and may be used in the same way and in the same proportions.

Soya Bean Cake.—This cake is greyish coloured, with a taste very much like pea meal, and is exceptionally rich in albuminoids (43 per cent.). At the same time it contains 6 per cent. of oil, 28 per cent. of carbohydrates, and 4 per cent. fibre.

It is very palatable and digestible, and stock like it. The cake is so rich in albuminoids that it is scarcely suitable or wise to feed it as the only concentrate, and is much better mixed with foods very rich in carbohydrates, *e.g.*, cereal grains. It is used in lamb foods, for dairy cows and fattening bullocks, and gives a good quality of flesh. There is no bad effect on dairy produce when it is fed to milking cows. It may be fed with other concentrates to the extent of 4 lbs. per head per day to dairy cows or fattening cattle.

Para Rubber Seed Cake.—Para rubber seeds are

now available in considerable quantity, and are being manufactured into cakes for feeding purposes. These cakes are light brown in colour and very friable, no doubt due to their richness in oil. Its composition, according to Auld, is as follows:—Albuminoids, 29·84 per cent.; oil, 20·11 per cent.; carbohydrates, 33·08 per cent.; fibre, 3·15 per cent.

Its digestibility was determined by Auld at Wye College with sheep, when all the nutrients showed over 90 per cent. digestibility:—Albuminoids, 90·1 per cent.; carbohydrates, 95·3 per cent.; oil, 97·2 per cent.; and fibre apparently all digested; hence this cake has a very high digestibility.

Maize Germ Cake.—Has a light grey colour, with the flavour of maize. The germ is removed from maize by the roller-mill process in the same way as is done at flour-mills. The germ being rich in oil and other nutrients, is prized as a food for stock. For convenience it is pressed into cakes.

The cakes, which are very digestible, contain: albuminoids, 21 per cent.; oil, 9 per cent.; carbohydrates, 44 per cent.; fibre, 9 per cent.

This is an excellent food for dairy cows, and may form a half to two-thirds of the concentrated part of ration.

Sesame Cake.—Manufactured from seeds of the sesame plant. It contains 40 per cent. albuminoids, 12 per cent. oil, 20 per cent. carbohydrates, and 7 per cent. fibre. The albuminoids and oil are largely digestible, but only about half the carbohydrates and one-third of the fibre.

(*c*) Oil-cakes—Fairly High in Fibre.

Cocoa-nut Cake.—Has a uniform brown colour with the cocoa-nut smell.

The composition shows: albuminoids, 22 per cent.; oil, 10 per cent.; carbohydrates, 36 per cent.; and *fibre*, 15 per cent. These cakes do not keep very well as the oil soon becomes rancid, producing acidity.

It is rather high in fibre, but the fibre appears to be fairly digestible and blends well with pulse and cereal grains.

The cake is very suitable for butter and milk production, and can be used to replace roots, like palm-kernel cake (see below).

Coprah Cake.—This is practically the same thing as the cocoa-nut cake above, but is made from the dried kernels of the cocoa-nut, called, in commerce, "coprah." The coprah is chiefly exported from the islands of South Pacific to this country, primarily for the oil it contains.

Palm-kernel or Palm-nut Cake.—Is a light grey colour with small dark specks in it, due to the palm kernel having a brown and fibrous outer part while the remaining part is white. When the nuts are ground up and pressed, it gives the cake a speckled appearance. It has a similar smell to that of cocoa-nut.

The cakes contain 17 per cent. albuminoids, 10 per cent. oil, 36 per cent. carbohydrates, and 22 per cent. *fibre*.

These cakes do not keep very well, as the oil is apt to go rancid. When fresh, they are a splendid food for all classes of stock, and fairly digestible. The cake has a laxative effect, and on this account is a useful substitute for roots when they are scarce. Dairy cows like it, and

it gives a firm and good flavoured butter, but should not constitute more than half the ration (4 lbs.).

Bean or pea meal goes well with it, and this combination is very suitable for pig-feeding, seeing that it gives a firm bacon. Being high in fibre, concentrates blended with it should be low in this constituent, and not too rich in oil.

Rape Cakes.—Generally dark brown in colour, made up in thick, flat, circular cakes. They are often yellowish on the outer surface, due to the presence of mustard seed which has found its way into the rape seed; such cakes have a biting taste. In fact, the cakes generally are not attractive to stock.

The composition is good: albuminoids, 32 per cent.; oil, 10 per cent.; carbohydrates, 29 per cent.; fibre, 11 per cent.

These cakes are apt to contain considerable quantities of sand, and do not keep too well.

When fed to dairy cattle they are supposed to give a hard butter, but may give it a turnipy flavour. Probably their greatest use is for including in compound cakes, as the undesirable flavour can be overcome by spices, etc.

Undecorticated Cotton Cakes vary from dull brown in colour (Bombay) to the yellowish colour (Egyptian). These include the hulls as well as the kernels of the cotton seeds, hence the name. The hulls are black, difficult to digest, and can be readily seen in the cake with the naked eye, hence the cake has a coarser appearance altogether than the undecorticated cotton cake. The black hulls have an astringent action, which may be an advantage when these cakes are fed along with immature roots, etc., which tend to scour animals.

The cakes also vary in appearance, according to the

amount of cotton lint that is left on the seed after ginning, and a few years ago feeders generally were afraid to give cakes containing a large amount of this cotton lint to their stock. Experience has now shown that these fears need not be entertained so long as the cakes are fed with ordinary caution.

The "Egyptian cotton cake" contains very little cotton lint, and is yellowish in colour, with the dark brown husks interspersed throughout the cake. It contains 5 to 6 per cent. oil, 22 per cent. albuminoids, 34 per cent. carbohydrates, while the percentage of fibre is as high as 20 per cent. It is a most useful concentrate for fattening cattle, especially in the earlier stages, and may be given up to 6 lbs. per head per day. For milking cows, it gives a pale but firm butter. Sheep being fattened on roots do well with it up to 1 lb. per head per day, but it should be fed carefully and only in very small quantities to young stock, as it is rather difficult to digest, seeing that only three-quarters of the albuminoids, half of the carbohydrates, and one-eighth of the fibre are digestible.

The Bombay cotton cake differs from the Egyptian in its distinctly woolly appearance, caused by the cotton lint adhering to the seed after ginning. It is not quite so rich in albuminoids (19 per cent.) or oil (4 to 5 per cent.), and has in addition a very "astringent" action. This is particularly valuable when cattle or sheep are receiving immature roots in the autumn, or young grass in the spring, as this cake counteracts the tendency to scour. Four to 6 lbs. per day is generally sufficient for a two-year-old bullock, and ½ lb., as part of the ration, for a "teg" or "hogg."

When purchasing undecorticated cotton cakes, one should avoid to a large extent those which are very

hard and show excessive coarseness of the husk. It is also a good plan to "nut" the cakes a few days before they are fed, as they absorb moisture and become very much softer. Nails, if present, are often detected in this manner before the cattle get an opportunity of swallowing them.

Kapok Cakes.—These cakes are obtained after the seeds have been ground, pressed, and made into cakes in the usual way.

The cake contains about 26 per cent. albuminoids, 6 per cent. fat, 20 per cent. carbohydrates, with 28 per cent. fibre. The high percentage of fibre is due to the seeds having very thick, hard hulls. The fat is nearly all digestible, three-quarters of the albuminoids, only half the carbohydrates, and one-fifth of the fibre.

Sunflower Cake.—This cake is not much used in this country, although on the European continent it is fed to dairy cattle. It has a fairly good composition, excepting it is high in fibre, as will be seen below: albuminoids, 19 per cent.; oil, 7½ per cent.; carbohydrates, 30 per cent.; fibre, 30 per cent.

It is considered to counteract to a large extent the tallowy flavour of the fat of bullocks and sheep.

Hemp Cake.—Residue from hemp seeds after oil extraction. The extraction of oil is often made at a high temperature, which sometimes causes the cakes to be burnt. They may also be acid in character, and this means that they should be very carefully fed to cattle, and not at all to horses and sheep.

The cakes contain: albuminoids, 31 per cent.; oil, 10 per cent.; carbohydrates, 18 per cent.; fibre, 20 per cent.

As this cake is poor in carbohydrates, high in fibre, and not very digestible, it should be fed in combination

with easily digestible foods, rich in carbohydrates, such as maize.

(*d*) Compound Cakes.

Thousands of tons of cakes which have been compounded or mixed from various sources are fed to farm live stock each year.

Frequently some material, such as ground cotton cakes, rape cakes, cocoa-nut cakes, etc., are taken as a basis, and along with this may be blended ground cereal grains, rice meal, bran, dried grains, etc., till the desired composition is obtained.

The mixed food is made palatable and appetising by the addition of condimental foods or spices, such as fenugreek, aniseed, etc., and sweetened with locust-bean meal or treacle. In this way, foods like rape cake, which would not otherwise be eaten by stock, are readily devoured when compounded with other foods.

Considerable care is required in purchasing compound cakes, as they furnish a ready means of getting rid of musty, faulty, or inferior cakes, warehouse sweepings, etc.

(*e*) Leguminous Seeds.

The chief leguminous seeds or pulse grains which are grown in this country are beans, peas, and tares. They are all fairly rich in albuminoids (beans containing 25 per cent. and peas 23 per cent.), but are very poor in oil ($1\frac{1}{2}$ per cent.). In carbohydrates, peas have 54 per cent. and beans 48 per cent. Fibre is low (6 to 7 per cent.). The following foreign leguminous seeds deserve special mention:—

"**Indian Pea or Gram**" (*Vigna catjong*) is about the same size as a field pea, dull greyish coloured, and

peculiarly shaped. It has the following composition: albuminoids, 18 per cent.; fat, 4 per cent.; and carbohydrates, 58 per cent. This pea is becoming increasingly popular for blending with other foods which are rather low in nutrient constituents.

Java Beans (*Phaseolus lunatus*) should be very carefully fed to stock, because, when mixed with the digestive juices, prussic acid may be generated, which is a deadly poison. The same thing applies to gorse seeds.

Leguminous seeds, and especially beans, are apt to produce flatulency (wind on the stomach, etc.), if fed carelessly to animals; on this account they should not exceed, say, a quarter of the concentrates fed. They should be well ground and mixed with bran and chop to make a bulky feed.

To the feeder these foods are highly nutritious, and are particularly useful for mixing with bulky rations as well as concentrates which are rich in oil. For horses doing severe work, beans and peas supply them with wonderful staying power and muscular energy.

(*f*) Cereal Grains.

These include wheat, barley, oats, rye, maize. They are only moderately rich in albuminoids (10 to 12 per cent.), but very rich in carbohydrates, since maize, rye, and wheat contain 70 per cent.; barley, 67 per cent., and oats, 57 per cent. The carbohydrates are present largely in the form of starch.

Maize and oats are comparatively rich in oil, and on this account are rather "heating" foods when fed to animals. All the rest are poor in oil (2 per cent.). The fibre is very low (2 per cent.), except in oats (10 per cent.) and barley (5 per cent.).

Rice, dari, and millet may also be included in this

group; the first two can be taken as approximately equal to maize in composition, except that they are slightly poorer in oil (rice, 4 per cent.; dari, 3¼ per cent.), while millet is about equal to oats.

To the feeder the cereal grains are almost indispensable for mixing with foods rich in oil and albuminoids and poor in carbohydrates (oil-cakes). With oil-cakes high in fibre, maize should generally be used. Oats are specially useful for all classes of stock, including calves. Cereal grains may form a very large proportion of the concentrated food in the ration for cattle, when rapid fattening is not required. For pigs they are sufficient by themselves for fattening purposes.

(*g*) Miscellaneous Seeds.

Acorns.—The fruits of the oak tree (*Quercus*) are shed on the ground in autumn, when they may cause acorn poisoning in cattle. Some varieties of oak are said to yield more poisonous acorns than others. The symptoms of acorn poisoning are:—"Progressive wasting, loss of appetite, diarrhœa, eyes sunken, sore places inside of mouth, in fact animal has a peculiarly haggard appearance. The temperature does not rise above normal, and is often below the normal temperature." See Board of Agriculture leaflet, No. 13.

Pigs relish the acorns, and with a plentiful supply soon put on flesh. The flesh, however, is apt to be soft and the fat oily.

The fresh acorns contain about 2½ per cent. albuminoids, 2 per cent. fat, and 35 per cent. carbohydrates. When dried, the amount of each constituent runs up to very nearly double in each case. The nutrients are very digestible.

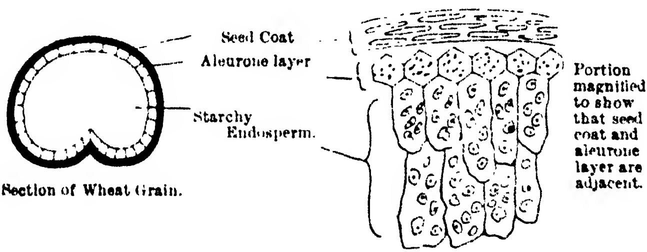
Buckwheat (*Fagopyrum esculentum*).—Is a triangular

seed with a fibrous coat. It is fairly rich in albuminoids (11 per cent.) and carbohydrates (55 per cent.), but poor in oil (2½ per cent.) and high in fibre (15 per cent.). Used chiefly for poultry.

(*h*) Wheat By-products.

In the production of "wheat flour" the wheat grain is divided during the milling process as follows:—(*a*) flour; (*b*) fine middlings, or seconds; (*c*) coarse middlings, thirds, or sharps; (*d*) bran. The last three are called "milling offals."

In order to understand milling offals better, one should know something of the structure of the wheat grain in section. The two diagrams divide the grain



Section of Wheat Grain.

into three parts, viz.: (1) seed coat; (2) aleurone layer, in which is concentrated, to a large extent, the gluten; (3) the kernel, which is a mass of cells containing starch. Roughly speaking, the coarser parts of the seed coat with part of the aleurone layer and some starch cells adhering, form the bran. That part of the kernel which is ground sufficiently fine gives the flour, and everything between the flour and the bran constitutes the middlings.

Milling Process.—British wheats may be divided into red wheats and white wheats, according to the

colour of the grain. The former are generally harder, and yield a flour with a greater "strength" or gluten-content than the latter; but the white wheats, and to a smaller extent the red wheats, excel all foreign wheats in giving a lovely white flour. In exceptionally hot seasons British red wheats may possess the requisite hardness and strength, but usually it is necessary to blend them with foreign wheats to supply these two characteristics to the flour. The advantages of so doing are that the harder wheats help the softer wheats to grind better, and the resulting flour gives a larger number of loaves per sack.

The Hereford Flour Mills were recently using the following blend, consisting of Indian wheat, 10 per cent.; Russian, 20 per cent.; Manitoba, 20 per cent.; English (red and white), 50 per cent. This blend would give about 96 loaves (quartern) to the sack, while average English flour would probably not yield more than 90.

The blended wheat is often washed and afterwards dried before it passes on to the series of roller-mills, consisting of about five in number. The first roller-mill gives a coarse "break," the second somewhat finer, while the last gives a very fine "break." All through the process the kernel is being separated from the bran and lighter portions of the grain by screening and currents of air.

Up to the second or even third breaks, the broken pieces of kernel, called "semolina," are kept separate from the rest and used for making the finest flour, as a whiter flour is obtained from the semolina.

The flour is separated from the middlings and bran by "silks," gauzes, and screens. Flour being the finest, passes through the finest silks; while the bran, being

coarsest, stops on the screens, the middlings coming between in coarseness. At an early stage the "semolina" and germ are separated by sieves or gauzes, the latter remaining on twenty wires to the inch, while the former goes through. In "standard" flour the germ was added to the flour. It is usual, however, to include the germ with the coarse middlings (*sharps*).

In the roller-mill process 65 to 75 per cent. of dressed wheat appears as flour, about 14 to 20 per cent. as bran, and 5 per cent. as middlings. The flour would be graded during the process into extra superfine, 30 per cent.; superfine, 45 per cent.; and fine, 25 per cent. Flour contains about 10 per cent. albuminoids, 75 per cent. carbohydrates, and 1 per cent. fat.

Fine Middlings (*Seconds*).—These consist of the finest portion of the milling offals, and contain albuminoids, 15 per cent.; oil, 3½ per cent.; carbohydrates, 62 per cent.; and fibre, 5 per cent. These have a rather "binding" tendency when fed to animals, and are useful for feeding with laxative foods. Ground linseed cake (laxative) and fine middlings (binding) when blended together make a splendid calf meal.

Coarse Middlings (*Sharps or Thirds*).—These come between bran and fine middlings in fineness, passing through screens with say eleven wires to the inch, and remaining on twenty to twenty-two to the inch. They contain the very fine bran and any flour adhering to same, plus the germ. Their composition would be about 1 per cent. richer in oil, and 5 per cent. poorer in carbohydrates, than fine middlings.

Bran.—Bran is the outer skin of the wheat, and often extends as deep as the aleurone layer, carrying with it a certain amount of flour. It is the coarsest part of the

milling offals, and is retained on a screen with eleven wires to the inch. Oftentimes it is separated into broad bran (over six wires per inch), and fine bran (under six and over eleven wires); the former commanding 20s. to 30s. per ton more than the latter. The coarse is generally used for horses and the fine for cattle.

Bran is a favourite food for all classes of live stock. Being bulky, it is useful for mixing with highly concentrated foods to open them up. When made into a mash with hot water, and fed to live stock, it has a laxative tendency.

It contains 14 per cent. albuminoids, 4 per cent. oil, 56 per cent. carbohydrates, and 9 per cent. fibre. The ash is rich in phosphates, but somewhat poor in lime.

(*f*) Barley By-products.

Brewers and distillers utilise various cereal grains for the production of alcoholic drinks—*e.g.*, beer, ale, etc.—on account of the ease with which the starch in these grains becomes converted into sugar by fermentation, and finally into alcohol. In the later stages of fermentation yeast is employed. Barley, however, is the grain most largely used for this purpose.

Good malting barley should be a pale clear straw colour, free from any discoloration by weathering in the field or heating in the stack. The awns should not have been broken off too close to the kernel. The grains should be uniform in size, with finely wrinkled husks, well fed, and the kernel free from flintiness; in fact, when cut across, the kernel should be white and starchy.

Malting of Barley.—The barley, after being steeped

in water at about 55° F. for two to three days, is spread out on the floor of a well-ventilated room in a layer 12 to 14 ins. thick. The enzymes in the grains begin to convert the starch into sugar in order to support the growth of the germ, oxygen is absorbed, carbon dioxide gas and heat evolved. The grain needs to be stirred periodically in order to aerate and cool it. After a few days it is sprinkled with water. In about fourteen days the sprouts have grown about ¾ in. long, and are ready for kiln drying. It has now arrived at the malt stage.

Kiln Drying.—The sprouted grain is removed to a kiln where the temperature can be regulated at will, and is gradually heated up to a temperature of 170° F. The sprouts are thereby killed and this heating process also gives the characteristic flavour, etc., to the malt.

The object of the malting is to remove most of the albuminoids from the grain as they interfere with the brewing process. These are mainly concentrated in the sprout, and can now be removed by screening, leaving behind the pure malt, which amounts to about 75 per cent. of the weight of barley taken.

Malt Coombs or Cummins.—Cummins are the sprouts which are removed by screening, and amount to about 4 per cent. of the original weight of barley. They contain about 23 per cent. albuminoids, 2 per cent. oil, 44 per cent. carbohydrates, and 12½ per cent. fibre.

Cummins are an excellent food for milk cows, and give to other foods a peculiar flavour and aroma, which makes them attractive to stock. They should be carefully fed to breeding stock, and kept in a dry room, or they may become mouldy. The sweepings from the drying kilns are called "kiln dust."

Brewers' Grains.—The pure malt is placed in the

huge tuns and made into a mash with hot water, to encourage the formation of sugar from the starch. In this way the sugar is dissolved out and removed in the sugary liquid called "wort," which is further fermented with yeast into beer, etc. The grains left behind in the mash tuns are removed and go under the name of "wet brewers' grains."

The "wet grains" may be carted away at once and used for cows in milk. If fed too freely, they are considered to have a prejudicial effect on the quality of the milk. They should be most carefully fed if they have become acid or mouldy.

The "dried grains" are wet grains with the bulk of the water evaporated off by heat (*i.e.*, desiccated) in order to make them keep. The drying reduces them to about one-quarter the weight of the wet grains. They can be fed to all classes of stock up to 6 or 8 lbs. per head per day as part of the concentrated diet, and supply a bulky food which opens up very rich foods such as decorticated cotton cakes, etc. Sometimes they are made into a mash for dairy cows. Their composition is as follows: —Albuminoids, 19 per cent.; oil, 5½ per cent.; carbohydrates, 45 per cent.; fibre, 19 per cent.

Distillery Grains.—These are very similar to brewers' grains, except that other cereal grains besides barley may be used, such as wheat, maize, oats, rice, etc., in order to supply the starch. The process of fermentation is not carried on quite so far, hence distillers' grains have a somewhat higher feeding value than brewers' grains. According to Dr Voelcker the oil and albuminoids may each be as much as 4 per cent. richer, and the carbohydrates and fibre respectively 4 per cent. poorer, than in brewers' grains.

(j) Oat By-products.

In the manufacture of oatmeal, the oats are kiln-dried before they are ground. This enables the meal to separate better from the hulls, which are subsequently screened off. The short silky hairs found on the thin end of the kernel are also separated and collected, giving what is called "oat dust." In this way about 60 to 65 per cent. of the weight of the oats taken appears as oatmeal, and 20 to 25 per cent. as offal. This shrinkage is largely a result of kiln-drying whereby a certain amount of moisture is lost. Probably three-quarters of the offal consists of oat hulls.

Oatmeal contains 7 to 8 per cent. oil, 11 to 15 per cent. albuminoids, 60 per cent. carbohydrates, and 3 per cent. fibre. It is a splendid food for human beings, and that grown in the Edinburgh district appears to be peculiarly suitable for this purpose.

For cattle it forms a very useful constituent of the concentrated part of the ration, especially when cattle are being fattened. Sometimes the oatmeal is made into a dough with hot water, moulded by the hands into balls, then fed to cattle in this ball form, say, 4 to 6 lbs. per head per day. This method answers where cattle are being fed off on grass-land.

Horses are fond of it, but it is only advisable to feed oatmeal when horses are doing hard work.

Oat Husks.—These husks have adhering to them a certain amount of oatmeal, which gives them a pronounced smell of the meal. They are high in fibre (30 per cent.), poor in albuminoids (3 per cent.) and oil (1 per cent.), but are very useful for opening up or separating highly concentrated foods, as well as

giving the whole feed a very attractive smell. The hulls are not very easily digested by stock.

Oat Dust.—Oat dust contains about 13 per cent. albuminoids, 5 per cent. oil, 50 per cent. carbohydrates, and 18 per cent. fibre. It is important for feeding purposes because it has an astringent or "binding" effect on the bowels of the animal, consequently it may be included with other foods which are rather too laxative, and for this purpose may be used up to one-quarter of the concentrates in the ration.

(*k*) By-products from Maize.

The chief by-products from maize which are being used for feeding purposes in this country at the present time are maize germ meal, gluten meal, and gluten feed.

Maize Germ Meal.—The maize is ground by the roller-mill process, after which the germ is removed and collected. The germ meal is rich in oil (10 to 12 per cent.) and carbohydrates (60 per cent.), and fairly rich in albuminoids (12 per cent.). It is very digestible, and suitable for dairy cows up to 6 lbs. per head per day.

Gluten Meal and Gluten Feed.—When maize starch is required, it is removed by careful washing from maize, which has been previously ground down to a meal. The residue consists of the germ, and, in fact, everything except the starch. It is divided into two grades, chiefly according to its richness or poorness in fibre. Those low in fibre (2 per cent.) are called gluten meal, while those containing a larger proportion of fibre (6 per cent.) are called gluten feed.

The gluten meal is also richer in albuminoids (38 per cent.) and oil (4 per cent.), but poorer in carbohydrates (45 per cent.) than gluten feed, which contains

albuminoids 26 per cent., oil 3 per cent., and carbohydrates 53 per cent.

These foods have proved themselves to be very suitable for dairy cows in the south-west of Scotland. (See Mr Robb's *Report*, Glasgow and West of Scotland Agricultural College.)

Flaked Maize.—This term is applied to maize which has been cleaned, crushed, cooked, rolled into "flakes," and dried. By so doing the bulk is considerably increased, and the palatability is improved; but it is very questionable if the cooking increases the digestibility, seeing that the oil and carbohydrates are practically all digestible in the uncooked maize.

Flaked maize is now being sold under the names of "Kositos" and "Uveco."

Maize Bran is the outer portion of the seed, and a similar product is being sold under the name of "Homco."

(*f*) By-products from Rice.

Rice meal is a by-product from rice mills, where the rice is being prepared for human consumption. It is rich in oil (12 per cent.) and carbohydrates (50 per cent.), moderately rich in albuminoids (12 per cent.), and contains about 8 per cent. of fibre. Sometimes rice hulls, which consist of hard, indigestible fibrous material, may find their way into the meal. It does not keep at all well, as the oil quickly decomposes.

It may be used for all classes of stock as part of the concentrated food, more especially with those foods which are rich in albuminoids and poor in oil.

(*m*) Miscellaneous By-products.

Apple Pomace, or the residue after the juice has been expressed from apples in cider-making, is fairly rich in carbohydrates.

The "fresh residue," according to Wolff, contains on an average: water, 75 per cent.; albuminoids, 1·6 per cent.; carbohydrates, 17·5 per cent.; fat, 1·2 per cent.; and fibre, 4·9 per cent. Half the albuminoids and fat, two-thirds of the carbohydrates, and rather less than half the fibre are digestible.

The "dried residue," on an average, contains: water, 15 per cent.; albuminoids, 5½ per cent.; carbohydrates, 49 per cent.; fat,[1] 3¼ per cent.; and fibre, 21 per cent. The digestibility bears about the same proportion for the different nutrients in each case as those in the fresh residue. It appears that considerable quantities of apple mast are sent to cake manufacturers, where it is no doubt blended with other foods in the manufacture of compound cakes. In Germany it is sometimes made into jam.

Spent Hops.—Spent hops are fairly rich in nutrients, containing, according to Wolff, about 16 per cent. albuminoids, 6 per cent. fat,[1] 40·5 per cent. carbohydrates, and 21 per cent. fibre. Half the carbohydrates, two-thirds of the fat, one-third of the albuminoids, and very nearly one-seventh of the fibre are digestible.

Dried Yeast.—Dried yeast and extracted yeast are being used in feeding rations, largely because they are rich in water-soluble B vitamin (see p. 41). At the same time these residues are very rich in albuminoids (49 per cent.) and carbohydrates (30 per cent.). It has

[1] Ether extract.

PLATE IV.

a very narrow albuminoid ratio (1 : 0·6) and a starch value approximately equal to that of rape cake and soya-bean cake (see p. 48). It may be used for all classes of farm live stock.

Fish Meal.—Fish meal consists of the residues of fish, such as heads, and other unnecessary parts after they have been heated with super-heated steam to extract the greater part of the fat, dried, ground down, and finally sifted to remove the coarser parts. It is exceedingly rich in albuminoids (50 to 60 per cent.), oil may be as high as 6 per cent., and in addition there will be about 3 per cent. common salt and 16 per cent. of phosphate of lime.

Fish meal made from herrings appears to be fairly rich in fat-soluble A vitamin, while that from white fish appears to be much less valuable in this respect.

Fish meal may be used for feeding farm live stock, provided it has been made from fresh, sound fish, has a low oil content, and is used with discretion; otherwise it may taint the flesh of those animals which are used for human consumption. In such cases, it is advisable to discontinue its use for at least two weeks before the end of the fattening period.

The amounts recommended are as follows: cattle (1000 lbs. live weight), 2 lbs. per head per day; sheep, $\frac{1}{10}$th to $\frac{1}{8}$th lb. per 100 lbs. live weight; pigs, $\frac{1}{4}$ to $\frac{1}{2}$ lb. per head according to weight; poultry, a maximum of 5 per cent. for chicks and 10 per cent. for adult fowls.

(n) Condimental Foods.

Fenugreek.—This is a leguminous plant (*Trigonella*), which produces seeds with an aromatic odour. The commercial fenugreek meal is made by grinding the

seeds down to a meal and removing the husk, bran, and coarser portions out of it. It is used as a spice or condiment, and for this purpose is sprinkled on unattractive or inferior foods such as hay, chopped straw, and bulky fodders generally. It can be bought at approximately 20s. per cwt.

For spicing inferior hay 1 cwt. may be added to 10 tons of hay.

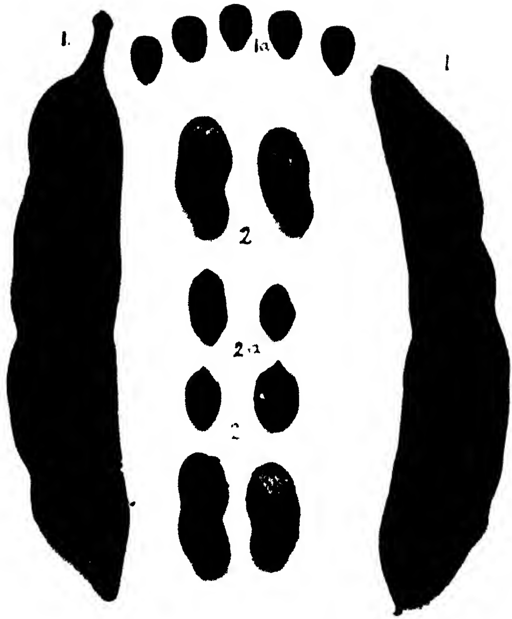
Locust Beans (*Ceratonia siliqua*).—The valuable part of the locust bean plant, or carob tree, for feeding purposes is the thick pod, which has a very sweet taste and agreeable smell. It grows in the Mediterranean district. The pods are carefully shaken off the tree while still unripe, and sun-dried. This ripens the pod and causes it to darken in colour. The seeds in the pod are very hard, hence it is usual to extract them, and retain the pods chiefly for stock-feeding purposes. The following is the composition: 6 per cent. albuminoids, $1\frac{1}{2}$ per cent. oil, 70 per cent. carbohydrates, and 6 per cent. fibre. The carbohydrates are all digestible.

The locust beans may be obtained on the market as:—

(1) *Nuts*, *i.e.*, broken down to approximately half-inch in length.
(2) *Coarsely ground meal*—about size of peas. The above are both very suitable for lamb foods, etc.
(3) *Medium ground meal*—fine for horses.
(4) *Finely ground meal*—used chiefly for spices.

Aniseed (*Pimpinella anisum*).—An umbelliferous plant, valuable for its aromatic fruits. It is used for spicing foods, and thus making them attractive to animals.

Gentian.—The root of the gentian plant (*Gentiana



1. Locust Beans (p. 82).
1A. Seeds of Locust Bean.

2. Earth- or Ground-nuts (p. [illegible]2).
2A. Seeds of Earth-nut.

[To face p. 88.

lutea) is first dried and then ground into a powder. It is a most valuable stomach tonic.

Coriander.—The fruit of the coriander plant (*Coriandrum sativum*) is used as an aromatic stimulant as well as a spice for inferior foods.

Ginger.—Commercial ginger is the rhizome of the ginger plant (*Zingiber officinal*). Rhizomes are dug up and plunged in boiling water for a few minutes, and dried in the sun (black ginger); or, if the outer skin is scraped till white after washing, it is called white ginger. When mixed with foods in the powdered form it helps to remove the gases which may accumulate in the stomach or intestines.

Cane Sugar Molasses.—This is the by-product obtained after the extraction of sugar from the sugar-cane and has a thick, black appearance, with a sweetish taste. It contains about 30 per cent. of cane sugar, and 30 per cent. of other sugars. It does not appear to have the same laxative effect as beet molasses, which contains 50 per cent. more salts than are found in cane sugar molasses. The molasses are used very largely for mixing with inferior or unpalatable foods in order to give them an agreeable flavour. Further, it is used for conditioning animals, and provides at the same time a useful laxative and appetiser. It should not be fed too freely to breeding animals, as it is believed by some to cause sterility.

Beet Sugar Molasses.—The molasses obtained from beet sugar factories is somewhat bitter, and very laxative. It contains a large amount of sugar (45 per cent.), which is present chiefly as cane sugar. Further, it contains about 13 per cent. of various salts. Beet molasses by itself is not suitable for feeding to farm animals, on account of its richness in alkaline salts,

chiefly potash; but if combined with, say, sphagnum moss, the latter neutralises and corrects to a large extent any harmful effects on animals which the beet molasses may possess.

Makbar.—Hops, after being used by the brewer, are taken, cleaned, mixed with cane sugar molasses and wheat meal. Hops are appetisers, and promote digestion. At the same time they form the absorbent for molasses.

Composition:—Oil, 2·05 per cent.; protein, 8·37 per cent.; carbohydrates, 60·07 per cent.; minerals, 6·26 per cent.

Molastella.—The absorbent in this case is tapioca meal. It is mixed with cane sugar molasses, giving a brownish coloured meal, and is made at the Tapioca Flour Mills in Java, from which place over 12,000 tons a year is sold.

Composition:—Oil, 0·30 per cent.; protein, 1·00 per cent.; carbohydrates, 72·35 per cent.; fibre, 5·15 per cent.; ash, 6·9 per cent.

Soya Treacle Cake.—The basis in this case is soya bean after all but 2 per cent. of oil has been expressed, then cane sugar molasses is added. The meal is previously cooked by a special process.

Composition:—Protein, 40 per cent.; oil, 2 per cent.; carbohydrates, 32 per cent.

Molascuit.—The absorbent for molasses in this case is the pith or finer parts of the sugar cane which remain after the sugar has been extracted. This is blended with the cane sugar molasses. The amount fed is ½ lb. to 5 lbs. according to age and kind of animal, and has approximately the following analysis:—

Protein, 1·88 per cent.; oil, 0·83 per cent.; carbohydrates, 66·88 per cent.; fibre, 6·76 per cent.

PLATE X

Molassine.—This, like molascuit, is made by adding cane sugar molasses to an absorbent (sphagnum moss), and has approximately the following composition:—

Protein, 6·30 per cent. (only one-fifth of this consists of albuminoids); oil, 1 per cent.; carbohydrates, 46 per cent. (three-quarters of this is cane sugar); fibre, 6 per cent.; ash, 8 per cent.

Dried apple pomace is sometimes used as an absorbent for molasses.

(o) Fodder Crops.

Clover hay is the richest fodder crop in albuminoids, containing 13 per cent. It also contains 2½ per cent. fat, 37 per cent carbohydrates, and 25 per cent. fibre; while meadow hay contains 10 per cent. albuminoids, 2½ per cent. fat, 42 per cent. carbohydrates, and 26 per cent. fibre.

The "cereal" straws (wheat, rye, barley, and oats) are poor in albuminoids (3 to 4 per cent.) and oil (1 to 2 per cent.). They are moderately rich in carbohydrates (33 to 38 per cent.), but these consist largely of various celluloses. They are, however, very high in fibre (37 to 44 per cent.), and in winter-sown cereals the fibre may be so high that, according to Kellner, 80 per cent. of the digestible nutrients of these cereal straws would be required to furnish sufficient energy for mastication, digestion, etc.

Oat straw and barley straw are equally rich in albuminoids (3½ per cent.), whilst wheat and rye straw contain 3 per cent. Fibre is highest in rye (44 per cent.) and lowest in oat straw (37 per cent.). The younger the straw is at cutting-time, the richer it is in albuminoids, and the lower it is in fibre; while

straw which is allowed to become dead ripe is very poor in albuminoids and very high in fibre.

The chaff (barren glumes) has a slightly higher nutritive value than the straw.

Leguminous straws are very much richer in nutrients than cereal straws. Pea straw is slightly richer in albuminoids (9 per cent.) than bean (8 per cent.), and in carbohydrates 34 per cent. as against 31 per cent. in bean straw.

Pea, bean, and vetch straws have all "a binding tendency," and require feeding in conjunction with some laxative food. The stems are rather coarse, but horses appear to relish them. The chaff (empty pods) has about the same nutritive value as clover hay.

To the feeder the fodder crops supply a bulky and fibrous food which opens up the concentrated foods, and by so doing allows the digestive juices to do their work more effectively. The term "bulky" means that a much larger weight of food is required to yield a given weight of nutrients than is the case with concentrated foods.

(p) Green or Forage Crops.

Common examples of forage crops are:—Lucerne, clover, vetches, pasture grass, rape, cabbages, swede and turnip tops. These contain a large proportion of water, varying from 76 per cent. in lucerne, 80 per cent. in pasture grass, and up to 88 per cent. in the case of turnip tops.

Lucerne is richest in protein (4½ per cent.); followed by clover and vetches, 3½ per cent.; pasture grass, 3 per cent.; rape, 2¾ per cent.; cabbages, 2½ per cent.; while turnip tops are poorest (2 per cent.).

The oil is less than 1 per cent. in all cases, while the carbohydrates and fibre are both less than 10 per cent.

The nutrients are considered to have a slightly less value in these green foods than those in cereal grains.

Green foods generally have a cooling and laxative effect on stock, although the leguminous crops are less potent in this direction than the other crops.

(*q*) Root Crops.

Potatoes, sugar beet, carrots, mangels, swedes, and turnips constitute what are called "root crops."

Potatoes and sugar beet contain about 75 per cent. water; carrots, 87 per cent.; mangels, 88 per cent.; swedes, 89 per cent.; and turnips, 90 per cent.; hence they are all very succulent foods. Large roots contain a larger proportion of water than smaller ones. Liberal nitrogenous manuring also increases the proportion of water in roots.

They are all very poor in protein (less than 2 per cent.) and oil (¼ per cent.). Potatoes are fairly rich in carbohydrates (21 per cent.), which is mostly present as starch; and sugar beet has 20 per cent., largely in the form of sugar; while the remainder have less than 10 per cent. In carrots, mangels, swedes, and turnips the carbohydrates are present largely as sugar, which is easily digestible. The fibre is at the same time low. Potash and soda predominate in the mineral matter, but it is rather poor in lime and phosphoric acid.

These root crops are bulky foods, hence they are fed more liberally to ruminants.

The chief characteristics of root crops to the feeder are that they supply a bulky and very succulent food, which has a cooling and laxative effect on farm animals, hence root crops are of immense importance in counteracting the costive tendency of straw crops and some of the concentrated foods.

Ash Constituents in Feeding Stuffs.

The ash constituents are usually present in sufficient quantity for the formation of bone and muscle. Those of most concern are phosphoric acid, lime, potash, and soda.

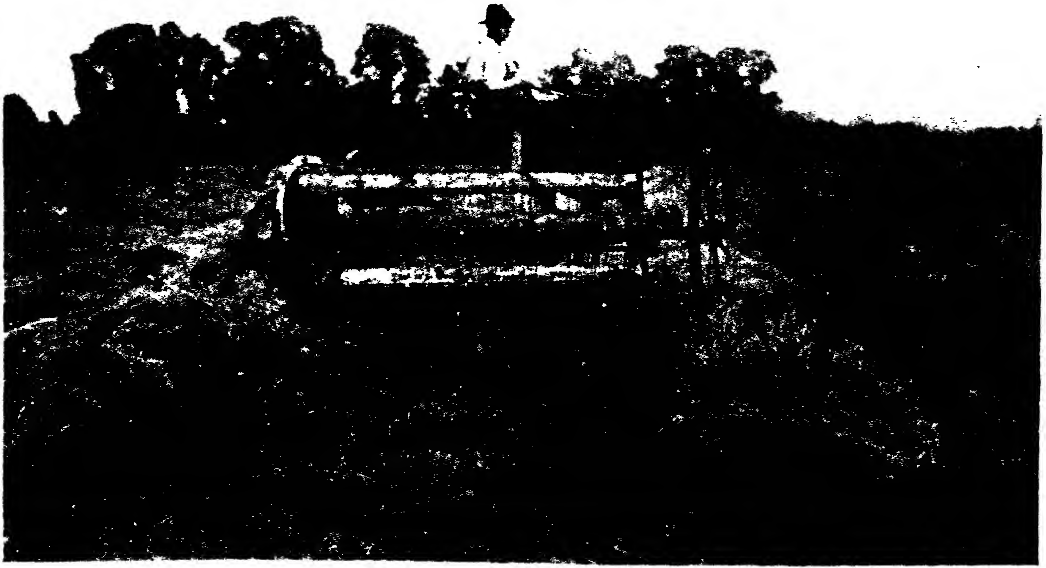
Oil-cakes and bran are comparatively rich in "phosphoric acid," while meadow hay is poor.

Leguminous straws—viz., bean, pea, vetch, clover hay—as well as leafy produce generally (*e.g.*, cabbages and turnip tops, etc.), are all comparatively rich in "lime," while cereal grains (especially maize and rice) and potatoes are poor in this constituent. If the drinking-water is hard, this may supply to some extent the deficiency in the food.

Roots, meadow and clover hay, leguminous straws, and oil-cakes are comparatively rich in "potash," while cereal grains are rather poor.

Many foods contain insufficient soda for the requirements of the animal body, and this is best supplied in the form of rock salt, so that the animal may regulate the quantity at will. Common salt should not be given to pigs or poultry, especially with sharps, which are slightly acid, otherwise some of them may suffer and even die from salt-poisoning.

PLATE VII.



English Haymaker.—The Side-delivery Rake can be adapted for turning the swaths or putting it into row for the Self-loader.

XIII. VARIATION IN COMPOSITIÓN OF PLANTS.

The chief causes which are responsible for variation in the composition of plants are: (1) climate; (2) variety; (3) manuring; (4) stage of ripeness when harvested; (5) weather conditions during harvesting and storage.

Climate.—It is well known that Canadian and Russian wheats are richer in gluten and poorer in carbohydrates (starch) than British wheats due to the shorter growing season and hotter climate in Canada and Russia than in Britain.

Flax seed grown on the European continent is richer in oil than that grown in Ireland.

Grieg and Hendrick (Aberdeen) found with reference to oat straw that it varied in different counties, *e.g.*, Morayshire straws were richer in albuminoids and lower in fibre than those under trial in Ross and Cromarty. In the former case the straw of Potato oat averaged 4·43 per cent. albuminoids and 40·45 per cent. fibre, while in the latter case the figures were 2·81 per cent. and 47·12 per cent. respectively. The explanation being that, in the cold, damp season of 1903, the straws of Potato oat as well as Storm King were favourably affected in the fine dry climate of Morayshire, but unfavourably affected in the moister climate of Ross and Cromarty.

Variety.—Red wheats have, generally speaking, greater "strength," *i.e.* are richer in gluten, than white wheats. At the same time they are correspondingly poorer in carbohydrates (starch).

With oats the proportion of husk varies with the variety. The husk of thin-"skinned" oats (Sandy Newmarket, Potato, etc.) would not generally exceed 25 per cent., while thick-"skinned" varieties (Storm King

and Tartar King), may go well over 30 per cent. of husk.

Grieg and Hendrick's experiments[1] showed that the composition of the "dry" oat kernel varied in different varieties; *e.g.*, Potato oat gave an average analysis in three counties of 9·30 per cent. oil and 15·5 per cent. albuminoids, while Storm King was poorer in oil (5·88 per cent.) but richer in albuminoids (16·51 per cent.).

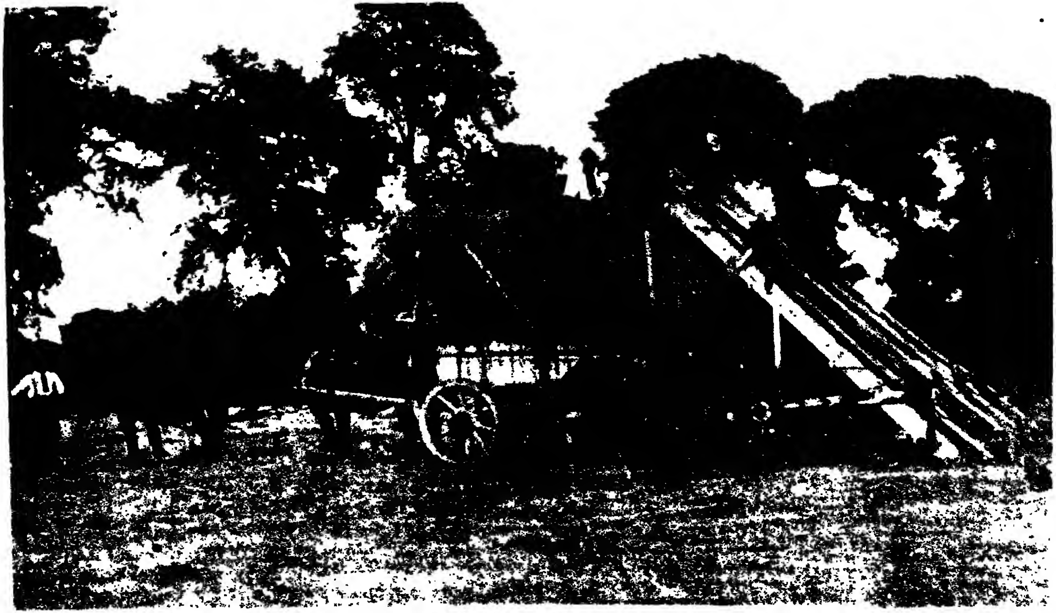
Straws from different varieties of oats in the same experiments also varied in composition. A striking point brought out was that straw from Storm King in Ross and Cromarty was lowest in fibre (44 per cent.), as against 47·12 per cent. in such a favourite oat straw as the Potato.

Manuring.—The size of the crop is very much increased by liberal manuring, owing to larger amounts of mineral matter and nitrogen being taken up in solution from the soil. The crop grows rank and sappy, consequently the nitrogenous matter is largely present in the form of amides. Heavy nitrogenous manuring would tend to increase considerably the proportion of water and probably double the protein in the plant, while phosphatic and potassic manures would tend to increase the proportion of carbohydrates, and, by causing the plant to mature earlier, the proportion of albuminoid nitrogen.

Small mangels may contain 2 to 3 per cent. less water than large mangels, and the carbohydrates be increased by the same amount; hence, ton for ton, small roots have a greater feeding value than large ones. This does not mean a small crop is better than a large one, but simply emphasises the fact that in a 30 or 40 ton crop (per acre) it is better to have the roots

[1] *Report*, 1905, Aberdeen College.

PLATE VIII.



[illegible]

of medium rather than of very large size; hence it is generally wise to leave the plants fairly close together at singling time.

In Ireland, it appears from a Report of the Department of Agriculture that "complete" mixtures[1] of artificials increased the bushel weight of oats.

At Garforth (1899 and 1900), Herbert Hunter carried out experiments to test the effect of various artificial manures on the composition and quality of barley. The report shows that a nitrogenous manure alone, or even with phosphatic manure in addition, adversely affected the quality, which was only improved when "complete" mixtures were used. A nitrogenous manure in incomplete mixtures appeared to increase the percentage of nitrogen in the grain, but when applied in conjunction with phosphates and potash, the proportion was hardly affected.

A phosphatic manure improved the yield of barley grain considerably, but had little effect on the proportion of phosphates in it. The potash manure did not influence the yield of grain greatly, but it increased the proportion of potash in the grain. The "complete" mixture gave the lowest percentage of nitrogen, and the highest percentage of potash.

Stage of Ripeness when Harvested.—This applies more especially to seeds and meadow hay and straw crops generally, as well as to roots. An example taken from Warington's *Chemistry of the Farm* will indicate the general effect on hay and, to some extent, straw crops.

The grass on 14th May was quite young; on 9th June it was in full flower; while on 26th June it was dead ripe. The table shows that as the plant matures,

[1] A "complete mixture" of artificials refers to those artificial manures which supply Nitrogen, Phosphates, and Potash.

the proportion of, nitrogenous matter and ash constituents diminishes, while the proportion of carbohydrates and fibre increases. At the same time the amides are largely converted into albuminoids. Young grass is richer in albuminoids and poorer in fibre than older grass. When both bulk and digestibility are taken into account, hay crops should be cut as soon as the majority of the plants are in full bloom, because after this point has been reached, the grasses become hard and brittle, due to the increased formation of fibre, and passage of nutrients into seed; consequently they are less digestible.

Table showing Variation of Composition of Meadow Hay.

Date of Cutting.	Nitrogenous Matter.		Oil.	Soluble Carbohydrates	Fibre.	Ash.
	Albuminoids.	Amides.				
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
14th May .	11·5	6·2	3·3	40·8	23·0	15·3
9th June .	9·4	1·8	2·7	43·2	34·9	8·0
26th June .	7·8	0·7	2·7	43·3	38·2	7·3

Weather Conditions during Harvesting and Storage.—If much rain falls while the grass is being made into hay, the grass may begin to ferment and turn yellow in the swath. This fermentation would cause some splitting up or decomposition of the nutrients, with evolution of carbon dioxide gas, hence food material would be lost. At the same time the rain-water would dissolve a certain amount of the soluble constituents out, especially the soluble carbohydrates and to a smaller extent the nitrogenous matter and fat, as will be seen in the following table.

PLATE IX.

English Haymaking. The Hay waggons are unloaded on to an Elevator, driven by a [illegible] or small oil-engine, [illegible] the Hay on the Stack.

Effect of Rain on Red Clover Hay (Bäesler's Analysis).

	Water.	Protein.	Fibre.	Fat.	Carbo-hydrates etc.	Ash.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Not rained on.	16·0	14·9	21·6	2·4	38·0	7·1
Rained on four weeks, 4½ ins. rainfall.	16·0	12·1	32·2	1·6	30·9	7·1

In the "heating of hay" the hay turns a bright yellow or brownish colour, and, if continued much further, ultimately black. Simultaneously a considerable amount of heat is generated.

When hay is stacked too soon, the heat generated may be so intense as to cause it to ignite (fire). Firing, however, does not take place until a few weeks have expired, as the heat has to drive off the surplus moisture before ignition will take place.

The drier the hay is made before stacking, the less will it heat. The more imperfect the drying process the more it will heat; hence, the presence of a certain amount of moisture encourages these fermentative changes, or the "heating" process. Warington points out that the soluble carbohydrates suffer most, the albuminoids at the same time being converted into amides, while the digestibility of the fibre is improved.

XIV. PERMANENT GRASS AND FORAGE CROPS.

The importance of a regular supply of green food on farms where live stock are kept from early spring to late in the autumn, can hardly be overestimated. Green food appears to be the natural food for milk, consequently a special attempt should be made to have a supply in the early spring for lambing ewes and

milking cows. In counties where the pastures are apt to fail in the hot summer months, forage or soiling crops have to be grown to tide over this dry period. This was more often the case in the days when seed mixtures containing rye grass and clover only were used for seeding down land to permanent pastures. Now, however, this difficulty can be largely overcome, if a suitable mixture of seeds is selected. The following hints will no doubt be found useful.

Permanent Pasture.

The ideal pasture is one which has a close turf and gives a regular and abundant supply of nutritious herbage throughout the growing season of the year. In order to secure such a pasture, it is necessary to include pasture plants which grow early in the year and those which grow late; plants of both tufted (top grasses) and creeping (bottom grasses) habits; those with deep tap roots as well as those with shallow roots. Further, it is important to include only those plants which are adapted to the particular soil and climate. A not unusual way of making up a pasture mixture at the present time is to include a small quantity of the seed of almost every grass and clover which has any feeding value at all. This system has some advantages but many disadvantages, inasmuch as it is expensive, and a number of second-rate pasture plants are introduced which produce only scanty feed for stock.

With the object of securing a good pasture mixture of maximum productivity on the most economical lines, the writer examined the herbage of a large number of the best pastures in the Border district of Scotland, and several counties in England, at various

PLATE X.

Seeding Down Land to Pasture.

[illegible] shows the result of using in [illegible] of the Herefordshire County [illegible] between the two seed mixtures.

seasons of the year. This enabled him to eliminate a number of pasture plants from the mixture which were often included, and include only those plants which were actually doing their duty in supplying abundant, succulent herbage for farm live stock.

The seeds mixture ultimately arrived at was as follows :—

	lb. per acre.
Italian rye grass	3
Perennial rye grass	8
Cocksfoot	5
Timothy	3
Meadow fescue	2
Meadow foxtail	1
Rough-stalked meadow grass	1
Giant hybrid cow clover or Montgomery red	2
Red clover (perennial)	2
Wild white clover	$\frac{3}{4}$
Birdsfoot trefoil	$\frac{1}{4}$
Burnet	3
Yarrow	$\frac{1}{4}$
Total seeds per acre	$31\frac{1}{4}$ lbs.

This mixture excels most other mixtures, inasmuch as it contains grasses and clovers along with a small proportion of special drought-resisting plants, such as burnet and yarrow. In fact, it is a modification of the Elliot mixture, but in the opinion of the writer and many practical farmers who have seen them growing side by side, is much more suitable on land up to 800 ft. elevation. In Herefordshire (1913), when pastures sown with local mixtures of seeds were quite burnt up with the hot, dry summer, those sown with a mixture similar to the above continued to give succulent feed for the stock.

In Roxburghshire, very similar mixtures are giving excellent results between 300 and 800 feet above sea-level, as at Charterhouse, Kelso, and Oxnam Neuk, Jedburgh.

When purchasing seeds for pasture mixtures it is most important to have a guarantee of the purity, germination, and bushel weight of the seeds.

Preparation of Soil.—The soil should be freed from weeds and well cultivated, so as to secure a good surface tilth. Unless the land is in "good heart," it should receive a dressing of slag (5 cwt.) and kainit (2 cwt.) in autumn to strengthen the clovers. This treatment has enabled many farmers to grow clover successfully on land which was considered to be "clover-sick."

Sowing Seeds.—The seeds are generally sown with a cereal crop, or with rape. Generally speaking it is advisable to divide the seeds into two parts, and sow one part in a direction at right angles to the other part, so as to ensure a more uniform distribution of seeds and a better turf.

After Management.—The land should be rolled both in autumn and spring if there is a danger of its being too loose. If the grass is cut for hay the first year, the plants should not be allowed to ripen before cutting, otherwise the plants will suffer. Thistles, if present, should be cut in the late summer as soon as the flowering heads have formed. Docks should be pulled up, when possible, immediately after heavy rain.

It is not advisable to graze a young pasture constantly with the same kind of stock, as it scarcely gives some of the plants a chance to spread and fill up the bottom. An occasional short rest of say two weeks gives plants like white clover an opportunity of spreading. On the other hand, a pasture should be sufficiently

26. Scotch Haymaking. Making the Tramp Coil at Mr David Young's, Mill Farm, Invergowrie, N.B. This method is very suitable under Scotch conditions where the rainfall is fairly high.

heavily stocked to prevent its becoming rough. Hard grazing is much better than the other extreme. An application of compost (lime and earth) is always effective in sweetening the herbage and strengthening the clovers.

Timothy Meadows.

The value of timothy hay for horses is probably not so widely appreciated as it should be. In the first place, the seed is comparatively cheap, and the grass flowers a fortnight or three weeks later than Italian rye grass, consequently the hay harvest does not all come in at one and the same time. Further, timothy yields a very heavy crop of hay of high feeding value.

Timothy thrives best on moist, deep soils, and should, generally speaking, not be sown on sandy or thin, dry soils. The seed is sown in the usual way with one of the cereal crops, at the rate of about 20 lbs. per acre. Seeing that the seed is so small, it is important to have the surface soil in a fine condition before the seeds are sown, so as to obtain successful germination.

In some cases meadow fescue[1] is included with the timothy, to the extent of 6 or 8 lbs. per acre, as it flowers approximately the same time (June) and yields hay of excellent quality. The mixture also ensures a more uniform crop. In other cases, Italian rye grass is included to give a fairly good crop of hay the first year. The rye grass may, however, smother the timothy somewhat the first year, and if included, should not exceed 8 lbs. per acre. The argument put forth is that timothy does not generally grow a full crop the first year, and Italian rye grass holds the land for the first year and then dies out, leaving the ground entirely to the timothy.

[1] A pound of rough-stalked meadow grass and ½ lb. white clover per acre are sometimes included to improve the aftermath.

Improving Poor Old Pasture.

There are several ways in which this may be brought about. Probably the first essential is that the land should be drained in some way or other; after this a suitable manuring will be required.

A very effective system is to lamb the ewes on a rough pasture. The ewes then tread all the rough grass away, and at the same time give the field a good manuring. After the sheep are taken out of the field, the herbage grows sweeter, and white clover develops, thus giving an excellent class of herbage for the stock.

In rough, sour, benty pastures a dressing of 2 to 4 tons cob (burnt) lime, or 10 cwts. ground lime per acre, sweetens the herbage very considerably. Composts of lime and earth are usually very effective.

Generally speaking, an excellent mode of procedure is to give the grass-land a dressing of 6 cwts. basic slag, and 3 cwts. kainit per acre. Experiments in connection with various agricultural colleges have shown that pasture land after being treated in this way has carried a much heavier stocking of sheep per acre, and produced a much larger amount of live-weight increase. (See reports of the Glasgow and Edinburgh Agricultural Colleges, also Cockle Park experiments.)

On soils rich in lime, potassic super (super and kainit) gives equally good results as at the Midland Dairy Institute, where dairy cows grazing on manured plots gave considerably larger quantities of milk.[1] On light soils a dressing of 4 cwts. of raw bone meal often brings about the desired effect.

[1] During the three years 1910-12, the average annual amount of milk produced from cows fed on the manured plots amounted to 93 galls. per acre more than that produced from cows fed on the unmanured plots.

PLATE XII.

[illegible]

Photo by Author.

Continental Haymaking. Carting home Hay with bullock waggon at Lauchstadt, near Halle, Germany.

Forage or Soiling Crops.

The term forage or soiling crop refers generally to those crops which are grown on arable land for their stems and leaves, and are cut and fed to stock in the green state. It is also usual to include rape and mustard, which are fed off by sheep on the ground.

These crops are all important in the south and east of England, where the climate is usually hot in summer, and the land is considered to be too dry to grow permanent grass satisfactorily. Hence the land is kept arable, and any green food which is required for live stock is grown in rotation cropping. The chief plants which are used for this purpose are:—

Rye, oats, barley, Italian rye grass, and maize; lucerne, sainfoin, vetches, trifolium and trefoil.

Rye, Barley, and Oats are sown either in the autumn or spring, and generally along with vetches, at the rate of 2 to 4 bushels of the cereal grain to 1 bushel of vetches. The resulting crop, which is bulky and very nutritious, can be cut about four to six months after sowing.

Italian Rye Grass can be seeded down in early spring at the rate of 2 to 2½ bushels per acre. It will then be ready for cutting the following autumn, and if well manured, may be cut three to five times the following year.

The rye grass may also be seeded down with a straw crop in the usual manner.

Maize.—This plant is now being grown more extensively in the South of England. The best variety is the "White Horse-tooth," which grows quickly and produces a large amount of succulent food. The seed

should not be sown earlier than June, and at the rate of 1 to 2 bushels per acre. In order to prevent to some extent the depredations of wood-pigeons, the seed should be treated with tar or red lead before sowing. The crop can usually be cut in August and September.

Lucerne (Alfalfa) may be sown down in April at the rate of 20 to 30 lbs. of seed per acre, either with a straw crop or without. If with a cereal crop, care should be taken not to sow the cereal too thick, otherwise it may smother the lucerne out. A dressing of basic slag and kainit with the cereal crop would strengthen the lucerne plants and make the crop more productive.[1] The following year the lucerne could be cut four or five times, and may be left down for three to five years.

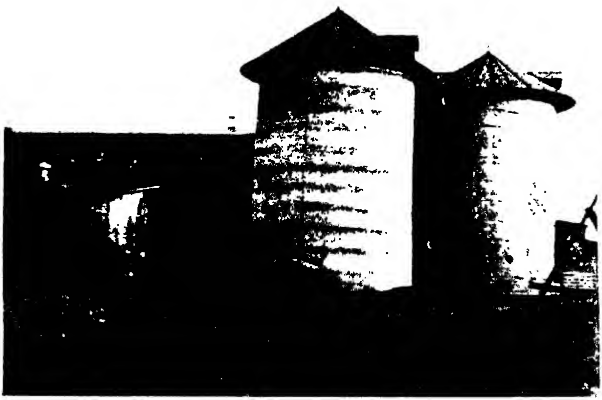
Sainfoin, which grows well on very dry, chalky soils, may be seeded down in the same way as lucerne, but with about 50 lbs. of milled seeds per acre. It may be cut frequently like lucerne, and can be left down for several years. One feature of it is that it thrives on dry chalky soils which are too poor for lucerne.

Vetches or Tares.—This is a most useful crop for forage purposes, and may be seeded down in "breaks" so as to supply a succession of green food during the summer and autumn. As mentioned above, cereal crops are often sown with this crop to support the vetches. Sow 2 to 3 bushels per acre.

Trifolium, or Crimson Clover.—This plant grows very rapidly, and the seeds are best sown in early

[1] At the West of Scotland Experimental Farm (Kilmarnock) the lucerne on plots, which had been inoculated with the nodule-forming bacteria for this crop, was much more vigorous than on the untreated plots.

1. Crop of Green Maize at the MacDonald Agricultural College, Quebec (p. 145).



Photos by Author.

American Silos.—Specially constructed to store Maize Silage.

[*To face p.* 100.

August, at the rate of 26 to 28 lbs. per acre. The crop can then be cut the following year. After it has been cut once, the plant dies.

Trefoil may be sown and utilised in very much the same way as trifolium. Twenty pounds of seed per acre is sufficient.

Rape.—If sown in July at the rate of 5 to 6 lbs. per acre, the leafage can be grazed off in the autumn.

White Mustard.—This would be sown in July or August at the rate of 20 lbs. per acre, and grazed in autumn.

XV. DIGESTIBILITY OF FOODS.

It is important to remember that the solid excrement represents the undigested part of the food after its passage through the alimentary canal. The other part therefore represents the amount which has either been digested, or, through fermentation in the alimentary canal, has escaped in the form of gas. Neglecting for the moment the possibility of a small amount being decomposed into gases and escaping in the breath or otherwise, the difference between the amount of the nutrients supplied in the food and that found in the solid excrement represents the amount which has been digested. It is then easy to calculate by difference the amount and proportion of albuminoids, oil, carbohydrates, and fibre digested respectively by the various classes of farm live stock.

The method adopted for this purpose is briefly as follows:—For convenience, a male animal is taken and fed on the experimental food for a week, to get the animal accustomed to the new diet as well as the old diet removed from the system. An indiarubber bag is then placed behind the animal so as to catch the

solid excrement. The food is carefully weighed and analysed before feeding, and the dung weighed and analysed by the same method as that employed for the food; then by subtraction the percentage of each nutrient digested in the food can be ascertained.

For very accurate determinations of digestibility a further precaution is necessary, more especially with ruminants. Since the food generally ferments in the paunch, gases (carbon dioxide, marsh gas, hydrogen) are generated and disappear in the breath. In a similar manner, food which ferments in the bowels of farm animals in general often decomposes with the evolution of gases which escape from the bowels; consequently in both cases this part of the food is not digested, and is therefore lost to the animal. It is only since the introduction of a respiration chamber[1] that the amount of loss in this way could be ascertained.

In this manner a large amount of useful information with regard to the composition of foods and the digestibility of same has been accumulated. Obviously it is only the digestible part which is available for maintenance and production, and for this purpose it is advisable to know that the proportion of digestible albuminoids is sufficient in the ration.

Individuality in Animals.—One thing which strikes the experimenter is the difference in results he obtains from fattening a given number of cattle, sheep, or pigs on a given ration. Although the individuals which

[1] The respiration chamber is an air-tight compartment which is used at a few research stations in Germany, where the animal is placed for short intervals during fattening, etc. The animal is supplied with air of known volume and composition, and from time to time it is drawn off and analysed. In this way the gases which leave the animal are discovered and their amount ascertained.

are being fed on the same ration may be of the same breed, may even be the same live weight at the commencement of the experiment, and may look a very level lot, yet at the close of the experiment the individual increases in live weight would vary considerably. Take, for example, the recent cattle-feeding experiments of the Edinburgh and East of Scotland Agricultural College (Report 31). In Lot I., which was fed on linseed cake and Bombay cotton cake with swedes and oat straw for nineteen weeks, the following results were obtained with three black cattle:—

Bullock.	Live Weight at Commencement.	Gained in Live Weight.
No. 10 . .	7 cwts. $3\frac{3}{4}$ qrs.	160 lbs.
No. 9 . .	7 cwts. 3 qrs.	224 lbs.
No. 1 . .	7 cwts. 1 qr.	350 lbs.

The different capacities of these three cattle for increasing in live weight during fattening is most marked, and is due to what is called their "individuality" or "individual capacity" for fattening. The same thing applies to horses, sheep, and pigs. There are "good doers" and "bad doers" in each class.

Further, the amount of food per day of a given ration which a two-year-old fattening bullock can stand varies with individual animals. One will show by the appearance of its dung that it is digesting it satisfactorily, while another will show that some of the food is passing through its body almost unchanged.

Ruminants and Non-Ruminants.—The following two tables are compiled from Kellner's figures, and show the comparative digestibilities of ruminants (sheep or cattle) as compared with horses and pigs.

Comparative Digestibilities of Nutrients in Various Foods by Horses and Ruminants (Kellner).

	Field Beans.		Oats.		Maize.		Lin-seed Cake.		Good Meadow Hay.		Red Clover Hay.		Wheat Straw.	
	Horse.	Ruminant.	Horse.	Ruminant.	Horse.	Ruminant.	Horse.	Ruminant.	Horse.	Ruminant.	Horse.	Ruminant.	Horse.	Ruminant.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Organic matter	87	88	69	70	89	90	66	79	58	67	51	56	21	42
Protein . .	86	87	80	76	76	72	81	86	63	65	56	54	28	4
Fat or oil .	13	83	71	80	61	89	52	92	22	57	29	53	...	31
Carbohydrates .	94	91	75	76	92	95	96	78	65	68	63	64	28	37
Fibre . .	65	58	29	28	40	58	...	32	48	63	37	46	18	50

The above figures show the proportion of each of the nutrients digested in both concentrated and bulky fodders.

Comparative Digestibility of Nutrients in Various Foods by Ruminants and Pigs (Kellner).

	Peas.		Maize.		Barley.		Field Beans.		Dried Brewers' Grains.		Clover before Flowering.		Clover beginning Flowering.	
	Ruminant.	Pig.	Ruminant.	Pig.	Ruminant.	Pig.	Ruminant.	Pig.	Ruminant.	Pig.	Ruminant.	Pig.	Ruminant.	Pig.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Organic matter	89	91	90	91	86	81	88	80	64	48	74	54	68	40
Protein . .	86	90	72	84	70	75	87	80	71	63	74	49	76	33
Fat or oil .	65	49	89	74	89	49	83	30	88	49	65	24	67	12
Carbohydrates	93	96	95	94	92	89	91	91	60	52	83	71	75	57
Fibre . .	46	70	58	41	—	12	58	15	48	15	60	24	53	16

The chief points to notice are that horses do not digest fat (ether extract) in foods nearly so well as ruminants, neither have they the same power of digesting fibre in bulky foods. Protein and carbohydrates in foods generally are digested just as well by horses as by ruminants.

Pigs digest practically as much protein in concentrates as ruminants, although in the bulky foods they compare less favourably. In the case of fat in foods, pigs are a long way behind ruminants, although they appear to digest it fully better than horses; *e.g.*, with beans the proportions are 30 per cent. as against 13 per cent. with horses; with maize, 74 per cent. against 61 per cent.; and with ground linseed cake, 80 per cent. against 52 per cent.

In the case of carbohydrates, pigs digest them in concentrated foods almost as well as ruminants, but in bulky foods the latter have the advantage.

The pig, however, has not much power of digesting fibre either in concentrated or bulky foods. Except with foods very low in fibre, the proportion digested does not reach 25 per cent. Horses, although non-ruminants, possess this power to a greater extent than pigs, on account of their enormously capacious bowels, including the blind gut (cæcum), where bulky foods may be temporarily stored and ferment a little, with the result that the fibre is rendered more digestible; but even then the proportion digested falls far short of that possible with ruminants when both are fed on bulky fodders.

Effect of Stage of Maturity on Digestibility.— This can best be illustrated from a hay crop, as it may be cut and harvested, (1) before it is in flower, (2) when it is in full flower, or (3) after it has passed full-flower

stage. The effect of cutting and harvesting hay at each of these three stages on the digestibility, is given in the following table, taken from Warington :—

Digestion by Sheep of Hay at Different Stages of Maturity.

Date cut.	Proportion of each Digested per 100 Supplied.				
	Total Organic Matter.	Nitrogenous Matter (Protein).	Fat.	Soluble Carbo-hydrates.	Fibre.
May 14th . .	75·8	73·3	65·4	75·7	79·5
June 9th . .	64·3	72·1	51·6	61·9	65·7
June 26th . .	57·3	55·5	43·3	55·7	61·1

The diminution of the proportion of each nutrient digested as the grass increases in age is very striking, and shows how difficult it is to generalise as to the composition and digestibility of hay crops.

Effect of Work.—The effect of work with, say, a horse, is to increase the respiration considerably. This means more oxygen is taken into the lungs and then into the blood, with the result that more oxidation of the food takes place and more heat is generated in the body. There is, at the same time, an increased demand on the food to meet the energy required to enable the horse to perform work ; hence it is reasonable to suppose that the harder or more difficult the work is, the greater will be the amount of food required (within limits). If, however, a food difficult to digest were given to supply the energy required for work, a larger proportion of the available nutrients would be required to overcome the mechanical difficulties of digestion before there would be any nutrients available for external mechanical work. Hence the importance of a concentrated and

easily digestible ration when horses are doing hard work.

Experiments do not show that a larger proportion of the food is digested when horses are at work; in fact, as the labour increases in intensity the reverse is the case. At the same time, a richer diet should be given and a larger amount of nutrients fed.

XVI. GENERAL CONSIDERATIONS IN COMPOUNDING RATIONS.

The general requirements of the animal vary with the kind of animal, its age, whether it is being kept in store condition or for purposes of production (meat, milk, or work). In order to meet these requirements the animals must be supplied with food; and in utilising the artificial foods for this purpose, one should, strictly speaking, keep in mind the following points:—

(*a*) The chemical composition and balance of nutrients.
(*b*) Digestibility of food used, and the albuminoid ratio.
(*c*) Utilisation of home-grown stuffs to the best advantage.
(*d*) Laxativeness of diet.
(*e*) Its palatability.
(*f*) Economy.

Composition.—It is obvious that a ration which is to meet the various requirements of the animal must be sufficiently rich in nutrient substances (albuminoids, fat, and carbohydrates). The proportions of each of these nutrients in the ration is a point of some importance, seeing that growth in size and the production

of nitrogenous† tissues (flesh, sinew, horny substance, hair, etc.) can, generally speaking, only be produced from the albuminoids in the food.

The fat and carbohydrates are quite as good as albuminoids, in fact better, for the production of heat, energy, and body fat. Further, the carbohydrates are much cheaper than albuminoids, which makes it advisable from a practical point of view to see that the proportion of albuminoids in the ration should not greatly or extravagantly exceed that which is necessary for the production of nitrogenous tissue in the animal body. Milk is fairly rich in albuminoids, hence milking animals require a more liberal allowance of albuminoids than cows which are not milking.

Another very important point is that the "fibre content" of the concentrated diet should be low, not exceeding 15 per cent. in fattening rations, and usually much less.

In practice, the suitability of a ration may be ascertained very approximately from its chemical composition so far as the balance of nutrients is concerned, and this method will be employed later on in the compounding of rations.

Although the balance of nutrients in the ration may be calculated sufficiently near for practical purposes from the chemical composition, yet it does not necessarily follow that the nutrients are capable of being digested by stock; hence, when one wishes to balance a food accurately, it is necessary to take into account the digestibility of each nutrient in the food. One is then able by calculation to tell whether the amount and proportion of digestible albuminoids are sufficient.

Albuminoid Ratio.—The "albuminoid ratio" is

defined as the ratio of the "digestible" albuminoids to the "digestible" non-albuminoids. Seeing that fat has a much higher value than carbohydrates for the production of heat and energy, it is usual to multiply the fat by 2·3 to get the non-albuminoids on a comparative basis; *i.e.*, 1 lb. fat is considered to be equal to 2·3 lbs. carbohydrates.

Two examples will give the method of arriving at the ratio, remembering that only the "digestible" part is taken in each case. The average digestibilities of most foods have been ascertained sufficiently near for this purpose (see pp. 48 to 51).

1. Linseed cake contains the following "digestible" constituents: albuminoids, 25 per cent; oil, 9½ per cent; and carbohydrates, 32 per cent.

Oil × 2.3 + Carbohydrates			: Albuminoids	will give the albuminoid ratio.
9½ × 2.3	+	32	25	"
21.85	+	32	25	"
53.85			25	2.15

Hence the albuminoid ratio is as 1 : 2·15. In other words, for every 1 part of digestible albuminoids in linseed cake there are 2·15 parts (or the equivalent) of carbohydrates.

Again, in an ordinary ration for a horse, the calculation is more involved, as there are several foods mixed together constituting the ration; *e.g.*, with a horse receiving per day 14 lbs. oats, 2 lbs. beans, 18 lbs. hay, and 10 lbs. swedes, we shall need to calculate the amount present in 14 lbs., 2 lbs., 18 lbs., and 10 lbs. respectively. The digestible nutrients in these foods are as follows:—

	Albuminoids.	Oil.	Carbohydrates.
	per cent.	per cent.	per cent.
Oats . .	9	$5\frac{1}{4}$	45
Beans . . .	19	$1\frac{1}{2}$	48
Meadow hay .	4	1	41
Swedes . .	$\frac{1}{4}$	$\frac{1}{10}$	8

Fourteen pounds of oats would then contain $\frac{14}{100}$th of the digestible constituents mentioned above; if, therefore, the digestible constituents for each food are multiplied by the number of pounds taken in the ration and divided by 100, the actual amounts of nutrients in the ration will be ascertained *E.g.*:—

Ration	Albuminoids		Oil		Carbohydrates	
	per cent	*lbs	per cent	*lbs.	per cent	*lbs.
Oats, 14 lbs. . .	14 × 9 =	1·26	14 × $5\frac{1}{4}$	0·73	14 × 45 =	6·30
Beans, 2 lbs. . .	2 × 19	0·38	2 × $1\frac{1}{2}$	0·03	2 × 48 =	0·96
Meadow hay, 18 lbs. .	18 × 4	0·72	18 × 1	0·18	18 × 41 =	7·38
Swedes, 10 lbs. . .	10 × $\frac{1}{4}$	·02	10 × $\frac{1}{10}$	0·01	10 × 8 =	0·80
		2·38		0·94		15·44

* The division by 100 is only shown by pushing the decimal place two places forward.

$\therefore$ 0.94 × 2.3 + 15.44 ÷ 2.38 will give the albuminoid ratio;

or 2.162 + 15.44 ÷ 2.38 " "

or 17.602 ÷ 2.38 " "

7·39.

Hence the albuminoid ratio of this ration is as 1 : 7·39.

Generally speaking, a "narrow" albuminoid ratio indicates a food rich in nutrients, a large proportion of which is albuminoids; while a wide ratio indicates a food low in nutrients. For young or fattening animals a ration with an albuminoid ratio of 1 to 3, or

in some cases 1 to 5, may be taken as supplying a sufficiency of albuminoids, but for maintenance this ratio may be widened considerably, say, 1 to 8 or 1 to 10.

It is from this point onward that several very interesting practical difficulties have to be overcome.

Home-grown Foods the Basal part of Ration.—Generally speaking, the rotation of crops adopted on arable land supplies the farmer with large quantities of straw and roots. Both these food-stuffs are bulky, and comparatively poor in nutrient constituents. The sale of these crops would involve a large amount of labour, and as their sale value is not high, it is usual to consume crops such as these on the farm by live stock, in order to convert them into a form (beef and mutton) which will be much more easily marketed. Hence the utilisation of these bulky foods in an economical way must be kept in mind in making up a ration. Concentrates are in reality only employed to make up the deficiencies in these bulky foods as required for the particular purpose.

Ruminants, on account of their special power of dealing with bulky foods (more especially fodder crops), consume the major part of the straw and roots on the farm. Horses, however, have fairly considerable powers of digesting these bulky fodder crops (see p. 104), but pigs have great difficulty in this direction.

Further, the bulky and fibrous nature of fodder crops (straw) throws a considerable amount of internal work on an animal, since it has to be chewed and mixed with saliva (masticated), carried along the alimentary track and dealt with by the stomach, intestines, etc. The work of the excretory organs is also increased, and it appears that the nutrients in bulky fodders have not

much value for the production of increase or energy, but are valuable chiefly for the production of heat in the animal body. Zuntz showed that with a horse fed entirely on wheat straw, which is one of the hardest and most indigestible of straws, that the energy required to deal with this hard, coarse food was greater than the energy supplied by the food; hence the horse ultimately died.

We have already seen that the production of work (external energy) and increase in body weight can only be obtained from the margin of nutrients which are left after the nutrients have supplied the animal with the necessary energy to deal with (masticate) the food in the mouth, as well as along the alimentary track till it leaves the system. The bulky part of the ration leaves such a small residue or surplus of digestible nutrients for production, that it is necessary to add concentrates to these bulky foods to raise the whole character of the ration.

This is brought about in the following way:—Concentrates are, generally speaking, foods which are rich in nutrients of high digestibility. The energy required for mastication, etc., is comparatively small, consequently there is a large surplus of nutrient material for production, and when added to the bulky food they raise the available surplus for production of each pound of the ration considerably above that of the original bulky food.

The concentrate by itself would not suit the peculiar digestive system of ruminants, which is intended by nature to deal with bulky foods. Bulky foods, therefore, serve a useful purpose in opening up highly concentrated foods, thus enabling the digestive juices to do their work more effectively.

Laxativeness.—Too much stress has probably been placed in the past on the actual chemical composition of the food, while what may be called in contradistinction the "mechanical" composition has been largely overlooked. By "mechanical" composition, is meant the ease or difficulty with which foods are masticated and passed through the alimentary canal. Foods like pasture grass, roots, linseed cake, bran, etc., pass along the food canal with comparative ease, and are called "laxative foods"; while others like hay, straw, Bombay cotton cake, and other concentrated foods high in fibre, only pass slowly or with difficulty, and are called astringent or "binding" foods. A ration extreme in either of these ways does not give the digestive organs a fair chance of doing their duty on the food. Scouring animals do not usually fatten or increase in live weight rapidly, nor do animals which are too stiff in the dung; a happy medium is eminently desirable, hence a great thing in making up a ration is to blend it so that it will pass through the animal at a rate which will enable it to get the maximum benefit out of the food.

The writer has studied the reports of most of the cattle and sheep feeding experiments which have been carried out in recent years in this country, and it appears fairly obvious that most of the disappointing rations which have been used have failed on the mechanical side, *i.e.*, in being too high in fibre and "too binding." On the other hand, palatable rations comparatively low in fibre, and correctly balanced, so far as laxativeness is concerned, have given much better results than their chemical composition would lead one to expect, provided the proportion of albuminoids was not too low.

In practice, the farmer has to use his judgment and vary the concentrate according to the bulky ration that

is available, *e.g.*, sheep receiving immature roots and hay require a binding concentrate like Bombay cotton cake. The same applies to cows on new grass in spring. On the other hand, a ration for a bullock may be too binding, and in this case a laxative concentrate (linseed cake, etc.) would be necessary.

It is difficult to over-estimate the value of knowing the percentage of fibre in concentrates when compounding rations, seeing that the fibre depreciates the value of the particular concentrate for fattening purposes. The Fertiliser and Feeding Stuffs Act only requires guarantees to be given by the seller for oil and albuminoids. This, however, is very good so far, but the Act would be even more valuable if, in addition, the fibre content had to be included in the guarantee. The farmers would then have the necessary particulars[1] on the invoice for making up rations.

Palatability.—There are some concentrates, *e.g.* rape cake, which are rich in nutrients, but, on account of their insipid taste or unpleasant aroma, are not relished by stock. The consequence is that the animal does not eat as much as is necessary, say, for rapid fattening, and in fact may not improve in condition at all.

On the other hand, if the food is attractive in flavour and aroma, the animal devours it with avidity, and consumes, if available, a larger amount of food. At the same time the flow of digestive juices on the food is stimulated to a much larger extent, consequently a larger quantity of food is digested and the animal benefits accordingly.

The great aim of the feeder is to have all the foods

[1] The actual composition of oil and albuminoids is often more accurately stated on the invoice, than would be the case if one took average figures from tables.

which he feeds to stock palatable, and if they are naturally deficient in flavour or aroma, he must add treacle, locust beans, etc., to sweeten them, and aromatic seeds, such as aniseed, fenugreek, etc., to give them an attractive smell (see pp. 81 and 148).

Economy.—In the making up of rations for farm live stock, the business farmer will keep in view the possibility of substituting one class of concentrated food for another (*e.g.* gram for beans), as long as the substitute is cheaper[1] and is equally suitable so far as the digestible constituents are concerned. Sometimes a flavourless, but otherwise good, substitute for a concentrate may be utilised provided it is made attractive by spicing.

Again, hay or grain which is not very good through being weathered during harvesting, may be utilised for feeding purposes, provided it is only fed in small quantities at a time after it has been mixed with other wholesome foods.

In certain cases, considerable saving might be effected by chaffing the bulky fodders, and bruising any grain that may be included in the ration. This, apart from avoiding waste, reduces the amount of energy required for masticating the food, thus leaving a greater surplus of nutrients for production (see p. 157).

XVII. FOOD STANDARDS.

Early History.—Professor Thaer, Halle University, was probably the first to make a serious effort to draw up comparative feeding values of different feeding stuffs, when in 1810 he published a table of "hay equivalents." In this table 100 lbs. hay were given as being equivalent in feeding value to 91 lbs. of clover or lucerne hay,

[1] For rough method of ascertaining whether foods are dear or cheap, see p. 139.

200 lbs. potatoes, 417 lbs. swedes, 602 lbs. cabbages, or 625 lbs. mangold-wurzels.

With the application of chemistry to agriculture in the latter half of the nineteenth century, Wolff published a new method in 1864, based on the digestible nutrients contained in the various feeding stuffs, and this method laid the foundation of our modern scientific methods of the feeding of farm live stock.

Several methods of arriving at food standards are in use at the present time, which have been arrived at in different ways. Some of them are obtained as deductions from experimental results and do not "directly" take into account in the calculations the digestible nutrients in the ration; while others go further, by taking into account "starch" values or even "calorific" values. Some of these different methods are given below.

The chief art in making up rations is to supply the animal with a balanced ration which is digestible, palatable, and sufficiently laxative.

Generally speaking, the basal part of the ration for horses, cattle, and sheep consists of home-grown bulky fodders (grass, hay, and straw) and roots. These are nearly all poor in albuminoids, fat, and carbohydrates. At the same time the fodder crops are very high in fibre, hence the need to enrich the ration for production purposes (beef, mutton, bacon, milk, work) by adding concentrated foods which are rich in albuminoids, fat, and carbohydrates, but usually low in fibre.

(1) The Approximate Method.

The concentrated part of the ration is the chief consideration in this method.

Horses.—A full-grown horse at work, receiving a basal ration of, say, 1½ stones hay and 4 to 7 lbs. roots

per day, should have the following conditions fulfilled in the concentrated part of ration :—

1. It should contain 12 to 16 per cent. albuminoids.[1]
2. It should contain 4 to 5 per cent. fat.[1]
3. It should not, as a rule, contain over 8 per cent. fibre.[1]
4. The quantity to feed should be approximately 1 lb. per 100 lbs. live weight.

To test a given ration, multiply the percentages of albuminoids, fat, and fibre by the number of pounds of each food in the ration, and divide the total percentages of each of the nutrients by the total number of pounds of concentrated food in the daily ration.

Take, for example, the following daily ration :—

Concentrates in Ration.	Composition.		
	Albuminoids.	Fat or Oil.	Fibre.
	per cent.	per cent.	per cent.
Cracked maize, 4 lbs.	10½	5	2
Bruised oats, 5 lbs. .	11	5	10
Bran, 3 lbs. . .	14	4	9
Bean meal, 2 lbs. .	25	1½	7

(a) Calculation of Percentage of Albuminoids in Concentrated Food—

Maize meal . .	4 lbs.	×	10½ per cent.	=	42
Bruised oats . .	5 „	×	11 „	=	55
Bran . . .	3 „	×	14 „	=	42
Bean meal . .	2 „	×	25 „	=	50
	14 „				189

∴ Percentage of albuminoids $= \frac{189}{14} = 13\frac{1}{2}$ per cent.

[1] These percentages refer to the total albuminoids, fat, and fibre respectively in the concentrates.

(*b*) *Calculation of Percentage of Oil in Concentrated Food*—

Maize . . .	4 lbs.	× 5	per cent.	= 20
Oats . . .	5 „	× 5	„	= 25
Bran . . .	3 „	× 4	„	= 12
Beans . . .	2 „	× 1½	„	= 3
	14 „			60

$\therefore$ Percentage of oil $= \frac{60}{14} =$ 4¼ per cent.

(*c*) *Calculation of Percentage of Fibre in Concentrated Food*—

Maize . . .	4 lbs.	× 2	per cent.	= 8
Oats . . .	5 „	× 10	„	= 50
Bran . . .	3 „	× 9	„	= 27
Beans . . .	2 „	× 7	„	= 14
	14 „			99

$\therefore$ Percentage of fibre $= \frac{99}{14} =$ 7 per cent.

This rather heavy ration for a work-horse meets the above requirements, and is therefore a "balanced" ration for a work-horse.

No account is taken of the carbohydrates, as, with ordinary food-stuffs which satisfy the above requirements, it may generally be assumed that they will be present in sufficient quantity.

Cattle.—Fattening bullocks, dairy cows, or very young cattle. Basal ration, straw and roots or hay and roots, or hay, straw, and roots.

(a) Bullocks in *early stages of fattening* with straw and roots: *concentrated* part of ration should contain :—

Albuminoids		15 to 20 per cent
Fat		4 to 6 „
Fibre . . .	(not exceeding)	15 „

Feed at the rate of ½ to 1 lb. concentrates per 100 lbs. live weight.

Take for example a daily ration for a two-year-old bullock weighing 800 lbs., allowing ½ lb. per 100 lbs. live weight.

Concentrates in Ration per Head.		Albuminoids.	Fat.	Fibre.
Maize meal . . .	2 lbs.	21	10	4
Egyptian cotton cake .	2 ,,	44	11	44
	4 lbs.	65	21	48
In Mixed Ration . .		16¼ %	5¼	12 %

(b) *Later stages of fattening* with straw and roots, *concentrated* part of ration should contain:—

Albuminoids . . . 20 to 25 per cent.
Fat . . . . 6 to 8 ,,
Fibre . . (not exceeding) 10 ,,

Feed at the rate of 1 lb. concentrates per 100 lbs. live weight.

Take for example a daily ration for a two-year-old bullock (8 to 9 cwts.):—

Concentrates in Ration per Head.		Albuminoids.	Fat.	Fibre.
Decorticated cotton cake	3 lbs.	123	27	24
Egyptian cotton cake .	2 ,,	44	11	40
Maize meal . . .	4 ,,	42	20	8
	9 lbs.	209	58	72
In Mixed Ration . . .		23¼ %	6½ %	8 %

(c) *Cows in milk* getting hay and roots, *concentrated* part of ration should contain:—

Albuminoids . . . 16 to 22 per cent.
Fat. . . . . 4 to 6 ,,
Fibre . . (not exceeding) 10 ,,

With a cow, weighing 8 cwts., and in full milk (3 galls. per day), the following would be a suitable daily ration in addition to hay and swedes:—

Concentrates in Ration per Head.		Albuminoids.	Fat.	Fibre.
Decorticated cotton cake	2 lbs.	82	20	16
Bran	2 "	28	8	18
Ground oats	3 "	33	15	30
Maize	3 "	31½	15	6
	10 lbs.	174	58	70
In Mixed Ration		17·4 %	5·8 %	7·0 %

The amount of concentrated food required by milking cows would be ¼ to ⅓ lb. for every pound of milk yielded per day; *e.g.*, a cow yielding 30 lbs. milk (3 galls.) should receive 7½ to 10 lbs. of concentrated food per day.

A better method is to give each milk cow ¾ lb. of concentrated food per day for every 100 lbs. live weight, in addition to 2½ to 3 lbs. for every gallon of milk yielded per day.

(d) *Very young animals.*—For very young growing animals which have to fatten at the same time, the following standard would be suitable for *concentrated* part of ration:—

Albuminoids	16 to 22 per cent.
Oil	5 to 7 "
Fibre	(not exceeding) 8 "

Feed 1 to 2 lbs. per 100 lbs. live weight.

Sheep.—Fattening "tegs" or "hoggs" would receive hay and roots in addition to concentrates. The concentrated foods should have the same composition as the standards for fattening cattle.

Allow 1 lb. for every 100 lbs. live weight.

Early lambs would require the same standard for concentrated food as very young animals, and be fed at the same rate, viz., 1 to 2 lbs. per 100 lbs. live weight.

Pig Fattening.—For pigs, six months old, receiving a gallon of skim milk per day, with a meal mixture containing:—

Albuminoids . . .	10 to 15 per cent.
Oil	2 to 4 "
Fibre . . (not exceeding)	6 "

Feed 2 to 4 lbs. concentrated food per day per 100 lbs. live weight.

Barley meal (6 lbs.) and skim milk (1 gall.) are considered to make a wonderfully good ration for a six to eight months' old fattening pig. The meal in this case contains albuminoids, 10 per cent.; fat, 2 per cent.; and fibre, 5 per cent.

With whey the proportion of albuminoids in the meal should approximate to the higher figure (15 per cent.). The addition of pea meal would help to bring about this result.

(2) The Danish Method.

The Copenhagen Experiment Station has established feeding standards which are being used by many of the co-operative associations in Denmark chiefly for the feeding of dairy cows and the fattening of pigs.

The "Danish food standard" is 1 lb. of (what is considered) standard grain, viz., barley and maize. The values of all ordinary foods used are expressed in terms of the amount which is considered equal to 1 lb. of barley or maize for feeding purposes. After many trials they regard the following equivalent amounts as being sufficiently accurate for practical purposes.

Equivalents of 1 lb. Barley or Maize (Danish Food Standards).

(1) *For Dairy Cows—*

Decorticated cotton cake and earth-nut cake	0·8	lb.
Linseed cake, rape cake, sunflower cake	0·9	"
Maize, barley, and wheat (standard grain)	1·0	"
Ground oats, wheat-bran	1·1	"
Cummins (malt sprouts)	1·2	"
Black treacle (molasses), dried sugar beet-pulp	1·3	"
Meadow and seeds' hay	2·5	"
Wet brewers' grains, straw chop or chaff	5·0	"
Green grass or clover, silage	8·0	"
Swedes, mangels, carrots, soiling crops	10·0	"
Turnips, fresh beet pulp	12·5	"
Fresh beet leaves	15·0	"

(2) *For Pigs—*

Barley, maize, wheat (standard grain	1·0	"
Palm-nut and other "oil" cakes	1·0	"
Wheat bran, rye meal	1·4	"
New milk	2·5	"
Boiled potatoes	4·0	"
Skim milk, buttermilk	6·0	"
Whey	12·0	"

(3) *For Horses—*

Oats, maize (standard grain	1·0	"
Seeds, hay	2·5	"
Green grass or clover	8·0	"
Carrots, swedes, mangels, soiling crops	10·0	"

The foods mentioned above include those fed to pigs and horses as well as those fed to dairy cows, and from this list suitable foods are selected for the building up of rations approximately on the following lines:—

"**Milking Cows**"—One "Danish standard" is allowed for every 150 lbs. live weight of animal; in addition, one standard for every 3 lbs. of milk produced per day, but the foods in the ration are selected in such a way as to supply a sufficiency of digestible

albuminoids. Take a cow which is 900 lbs. live weight, the "food standards and requirements of digestible albuminoids" would be as follows:—

Daily Milk Yield.	Danish Food Standards required in Ration.	Minimum Requirements of Digestible Albuminoids in Ration.
1 gall.	9½	1 lb.
2 "	13	1½ "
3 "	16	2 "
4 "	22	2¾ "

An example will illustrate how to ascertain if a given ration conforms to this standard. With a cow giving 3 galls of milk per day the same ration may be taken as the one for milk cows (p. 120).

Ration per Head	Digestible Albuminoids, per cent. in Foods taken.	Digestible Albuminoids in lbs. in Ration.
Swedes, 30 lbs. . . .	0·25 per cent	0·075 lb.
Hay, 17½ lbs.	4·0	0·700 "
Decorticated cotton cake, 2 lbs.	34·0	0·68 "
Bran, 2 lbs. . . .	10·0	0·200 "
Oats (crushed), 3 lbs. . .	9·0	0·270 "
Maize meal, 3 lbs. . . .	7·0	0·210 "
Digestible Albuminoids in Ration . . .		2·135 lbs.

Ration per Head	Amount Equal to One "Food Standard"	Food Standards in Ration
Swedes, 30 lbs.	10 lbs.	3
Hay, 17½ lbs.	2·5 "	7
Decorticated cotton cake, 2 lbs.	·8 "	2·5
Bran, 2 lbs. . . .	1·4 "	1·4
Oats (crushed), 3 lbs. . .	1·1 "	2·7
Maize meal, 3 lbs. . .	1·0 "	3·0
Food Standards in Ration		19·6

The requirements according to the Danish standard for a cow giving 3 galls. of milk per day are:—16 food standards and a minimum of 2 lbs. digestible albuminoids; hence the above ration is more than sufficient. It will be noticed that in calculating these standards the fodder crops and roots are included in the calculations.

Fattening Pigs.—Weaned pigs are divided into four groups or classes, according to live weight, viz.—

1. Under 40 lbs.
2. 40 to 60 lbs.
3. 60 to 120 lbs.
4. 120 to 200 lbs.

The rations allow for each pig receiving from two up to about six food standards according to age, and as skim milk is a very common constituent of Danish fattening rations, they are made up on the following lines:—

Class.	Food Standards in Ration.	Proportion of each Constituent in Ration.		
		Skim Milk.	Barley Meal, or its Equivalent in Meals.	Roots, or Green Foods.
		per cent.	per cent.	per cent.
1	2 to 3	30	70	...
2	3 to 4	25	70	5
3	4 to 5	15	75	10
4	5 to 6	12	83	5

A pig in class 3 (60 to 120 lbs. live weight) may receive a ration of nearly ¾ gall. skim milk, 5 lbs. barley meal, and 3 lbs. boiled potatoes. This will work out as follows:—

Ration.	Amount Equal to One Food Standard.	Food Standards in Ration.	Proportion of each Constituent in Ration on Food Standard basis.
Skim milk, 6 lbs.	6	1	16 per cent.
Barley meal, 4½ lbs.	1	4½	75 "
Boiled potatoes, 2 lbs.	4	½	9 "

The proportion of each food in the ration is very approximately correct, but we have six food standards in the ration when there should be between four and five; hence by reducing each food in the ration by one-sixth, we should have five food standards in the daily ration. The correct mixture would then be 5 lbs. skim milk (½ gall.); barley meal, 3¾ lbs.; potatoes, 1¾ lbs.

(8) Swedish System.

The Swedish system is very similar to the Danish system; but one kilo (2·2 lbs.) is taken as the standard instead of one pound (1 lb.). Professor Nils Hansson has worked out the equivalent food standards in rather greater detail from the returns of the cow testing associations in Southern Sweden, and they apply specifically to the feeding of dairy cows. These are as follows:—

	Feed Units
Grain—	
Linseed	0·6
Maize	0·95
Barley, wheat, rye, peas, beans, tares	1·00
Oats	1·20
Oil-cakes—	
Earth-nut, sesame, soya-bean cakes	0·8
Decorticated cotton cake	0·85*
Linseed cake, cocoa-nut cake	0·9
Palm-nut cake	1·0
Undecorticated cotton cake	1·4
Various Feeds—	
Dried Yeast	0·8
Gluten feed	0·95
Rice meal	1·1
Wheat bran	1·2
Dried grains, malt coombs, molasses	1·3
Wet grains	5·0

	Feed Units.
Fodder Crops—(Hay and Straw)	
Red clover, and alsike clover hay	2·2
Meadow, timothy, lucerne, pea and vetch hay	2·5
Oat and vetch hay, barley hay	2·7
Oat hay	2·9
Pea straw, bean straw	3·5
Oat straw, barley straw	4·0
Root Crops—	
Carrots	8·0
Mangels	9·0
Swedes	10·0
Turnips	12·5
Forage or Soiling Crops, etc.—	
Timothy grass, meadow grass	5·3
Italian rye grass	6·0
Pasture grass	6·3
Perennial rye grass, mixed grass and clover	6·5
Green clover, green rye, green oats	7·0
Green lucerne (alfalfa)	7·5
Green maize, green oats and vetches	10·0
Green vetches, green peas	10·7

The Swedish feeding standards for milking cows are approximately the same as the Danish ones given above. They allow 1 feed unit for every 150 lbs. Live weight of the cow, and one additional feed unit for every 3 lbs. of milk produced. The minimum of digestible albuminoids in the ration should allow 0·65 lb. per 100 lbs. live weight of cow, together with 0·5 lb. for every 10 lbs. of milk produced.

(4) The Kellner Starch-Equivalent Method.

Dr Kellner, the late Director of the Animal Nutrition Experimental Station, Mochern, Leipzig, after much laborious and careful work with the aid of a Respiration Chamber, found that Wolff's standards, which were

based on the total digestible nutrients (albuminoids, fat, and carbohydrates) in a feeding stuff, did not give an accurate measure of its feeding value to the animal. In arriving at the actual value to the animal, he deducted from the total available energy supplied by the various digestible nutrients in a given feeding stuff, the energy used up in the mastication, digestion, and assimilation of the particular feeding stuff. The balance obtained in this way represents the "effective" available nutrients in the food to the animal.

On these lines, Kellner worked out the "effective" or "productive" values of the different nutrients, and after selecting digestible starch for his unit, he was able to get comparative values for the other nutrients in the food: these comparative values were called the "starch equivalent" of the particular nutrient and were found to be as follows :—

1 lb. of digestible albuminoids	0·94 lb. starch equivalent
1 lb. of digestible fat in coarse fodders, chaff, roots, and their by-products .	1·91 lb. " "
1 lb. of digestible fat in cereal and pulse grains .	2·12 lbs. " "
1 lb. of digestible fat in oil seeds and oil cakes .	2·41 lbs. " "
1 lb. of digestible carbohydrates (including digestible fibre)	1·00 lb. " "

The following points should be kept in mind, in calculating the "starch equivalent" of any given food-stuff :—

1. Digestible nutrients only are included.

   The amides must be deducted from the crude digestible albuminoids, and the "true" digestible albuminoids alone used in the calculation.

3. Food-stuffs that have not a so-called "full value

must have a proportionate deduction made from their gross starch equivalent (see pp. 48 to 51).

The method of estimating the starch equivalent of any given food from the digestible nutrients is approximately as follows :—

Food.	Crude Digestible Nutrients.*				True Digestible Albuminoids (i.e. Crude Albuminoids less Amides)	Proportion of "Full Value." (Full value = 100.)
	Albuminoids.	Fat.	Carbohydrates	Fibre		
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Maize . .	7·1	3·9	65·7	1·3	6·6	100
Linseed cake	28·8	7·9	25·4	4·3	27·2	97
Oat straw .	1·3	0·5	16·5	20·9	1·0	43
Swedes .	1·2		7·6	0·9	0·3	85

* The digestible nutrients in the four foods selected were not taken from the table on pp. 48 to 51, hence the starch equivalents are not quite the same. They had to be derived from other sources, simply to show the method employed.

Taking these foods as examples, the starch equivalents in each case would be :—

	Maize.		Linseed Cake.	
Albuminoids . .	6·6	× 0·94 = 6·204	27·2	× 0·94 = 25·568
Fat	3·9	× 2·12 = 8·268	7·9	× 2·41 = 19·039
Carbohydrates .	65·7	× 1·00 = 65·700	25·4	× 1·00 = 25·400
Fibre . . .	1·3	× 1·00 = 1·300	4·3	× 1·00 = 4·300
		81·472		74·307
Starch equivalent		$81·472 \times \frac{100}{100} = \underline{81·472}$		$74·307 \times \frac{97}{100} = \underline{72·08}$

	Oat Straw.		Swedes.	
Albuminoids . .	1·0	× 0·94 = 0·940	0·3	× 0·94 = 0·282
Fat	0·5	× 1·91 = 0·955	—	— —
Carbohydrates .	16·5	× 1·00 = 16·500	7·6	× 1·00 = 7·600
Fibre . . .	20·9	× 1·00 = 20·900	0·9	× 1·00 = 0·900
		39·295		8·782
Starch equivalent		$39·295 \times \frac{43}{100} = \underline{16·897}$		$8·782 \times \frac{85}{100} = \underline{7·465}$

The starch equivalents of the various feeding stuffs will be found ready calculated on pp. 48 to 51. It will be noticed that true digestible protein is given in the table (*i.e.*, the amides have been deducted in the percentages given), hence the calculation of starch equivalents could be made quite easily from the actual digestible nutrients given as well as the "value" of the food for production purposes, which has been inserted for the benefit of those who wish to calculate the starch equivalents of particular foods.

The "Kellner" Food Standards.—The Kellner Food Standards take into account three things, so far as the chemical composition is concerned, viz.:—(1) Dry matter in total rations; (2) "true" digestible albuminoids; (3) starch equivalent. For convenience, the food standards for cattle and horses are given per 1000 lbs. live weight, and with very young dairy cattle, sheep, and pigs per 100 lbs. live weight, especially when the live weight of a two-year-old bullock and a young dairy cow will be approximately 1000 lbs., and that of store pig (say 4 months old) and a store sheep (teg) would be roughly 100 lbs.

Per 1000 lbs. Live Weight.	Dry Matter in Total Ration.	True Digestible Albuminoids.	Starch Equivalent.
	lbs.	lbs.	lbs.
Full-grown bullock (maintenance diet)	15 to 20	0·6 to 0·8	6·0
" " (fattening diet) . .	24 " 32	1·5 " 1·7	12·5 to 14·5
Milking cow (giving 1 gallon per day) . .	22 " 27	1·0 " 1·3	7·8 " 8·3
" " (" 2 gallons ") .	25 " 29	1·6 " 1·9	9·8 " 11·2
" " (" 3 " ") .	27 " 33	2·2 " 2·5	11·8 " 13·9
" " (" 4 " ") .	27 " 34	2·8 " 3·2	13·9 " 16·6
Working horse (medium work) . .	21 " 26	1·4	11·6

Per 100 lbs. Live Weight.	Dry Matter.	Albuminoids.	Starch Equivalent.
	lbs.	lbs.	lbs.
Calves (3 to 6 months old, say 300 lbs. live weight)	2·4	0·28	1·47
Calves (6 to 12 months old, say 500 lbs. live weight)	2·6	0·23	1·25
Young cattle (12 to 18 months old, say 700 lbs. live weight)	2·6	0·18	1·05
"Fattening" sheep (Tegs)	2·4 to 3·2	0·16	1·45
"Fattening" bacon pigs, 1st period .	3·6	0·45	3·20
" " 2nd " .	3·2	0·35	2·65
" " 3rd " .	2·8	0·30	2·45

It will now be interesting to test the ration given for a dairy cow on p. 120, by the Kellner standard, and by reference to the table on pp. 48 to 51, the dry matter, starch equivalent as well as the "true" digestible albuminoids, can be obtained for each food.

1. *Dry Matter.*—

Ration per Head.	Percentage of Dry Matter in Food.	Pounds of Dry Matter in Ration.
Swedes, 30 lbs.	11½	3·45
Hay, 17½ lbs.	86	15·05
Decorticated cotton cake, 2 lbs. .	92	1·84
Bran, 2 lbs.	87	1·74
Oats (crushed), 3 lbs. . . .	87	2·61
Maize meal, 3 lbs.	89	2·67
Total Dry Matter in Ration		27·36 lbs.

2. *Digestible Albuminoids.*—These have been calculated out on p. 123, and amounted to 2·135 lbs.

3. *Starch Equivalent.*—The starch equivalents in table (pp. 48 to 51) are given per 100 lbs. of the particular food, and for calculating rations it is a convenience to

divide it by 100, and use the starch equivalent per 1 lb. of food.

Ration.	Starch Equivalent per 1 lb. of Food.	Starch Equivalent in Ration.
Swedes, 30 lbs.	0·07 lb.	2·10 lbs.
Hay, 17½ lbs.	0·31 „	5·425 „
Decorticated cotton cake, 2 lbs.	0·71 „	1·42 „
Bran (wheat), 2 lbs.	0·47 „	0·94 „
Oats (crushed), 3 lbs.	0·63 „	1·89 „
Maize meal, 3 lbs.	0·84 „	2·52 „
Total Starch Equivalent for Ration		14·295 lbs.

The above ration, therefore, provides 2·135 lbs. digestible albuminoids and 14·295 lbs. starch equivalent. Hence, when judged by the Kellner standard for cow giving 3 galls. milk (see above), it is a little low in digestible albuminoids, and higher than need be in starch equivalent. To correct these points, increase the cotton cake to 3 lbs., decrease the crushed oats and the maize meal to 2½ lbs. and 2 lbs. respectively. The corrected ration will then give 2·36 lbs. digestible albuminoids and 13·85 lbs. starch equivalent, which conforms to the Kellner standard.

Adjusting Kellner Standard to Individual Cases.—Take for example milking cows. These would vary in live weight, as well as in milk yield, and it is convenient to consider these two points separately, in order to arrive at the total food requirement.

(1) *Maintenance Ration according to Live Weight of Cow.*—Kellner points out that the maintenance requirement per day of a full-grown ox per 1000 lbs. live weight is: 0·6 to 0·8 lb. (average 0·7 lb.) digestible protein,[1]

[1] For an in-calf cow the digestible protein only should be increased to 0·75 lb. per day.

6 lbs. starch equivalent, with 15 to 21 lbs. dry matter, and it is assumed that the maintenance requirement of a dry cow would be the same.

It would appear that when a cow is receiving additional food for productive purposes (*i.e.*, milk) the digestible nutrients required are roughly proportional to the body weight. Hence the maintenance requirements for cows of different live weights would be as follows:—

Live Weight of Cow	Digestible Albuminoids	Starch Equivalent
8 cwt.	0·627 lbs.	5·376 lbs.
9 ,,	0·706 ,,	6·048 ,,
10 ,,	0·784 ,,	6·720 ,,
11 ,,	0·862 ,,	7·392 ,,
12 ,,	0·941 ,,	8·064 ,,

(2) *Production Ration according to Milk Yield.*—If one takes Kellner's standard rations for cows giving different quantities of milk, and deducts the standard maintenance rations, the differences will give the required feeding standards for varying milk yields. Taking average figures in each case, the production standards according to milk yield would be as follows:

Milk Yield.	Digestible Albuminoids	Starch Equivalent.
(1) 10 lbs. per day	0·45 lbs.	2·05 lbs.
(2) 20 ,,	1·05 ,,	4·50 ,,
(3) 30 ,,	1·65 ,,	6·85 ,,
(4) 40 ,,	2·30 ,,	9·25 ,,
Higher yields, add per gallon	0·60 ,,	2·50 ,,

(3) *Total Ration Required.*—It is now quite easy to

arrive at the food standard for, say, a 12 cwt. cow giving 40 lbs. (4 gallons?) of milk per day, viz.:—

	Digestible Albuminoids.	Starch Equivalent.
Maintenance ration for 12 cwt. cow . .	0·941 lb.	8·064 lbs.
Production ration for 40 lbs. milk per day	2·300 ,,	9·250 ,,
Total ration required per day . .	3·241 lbs.	17·314 lbs.

Professor Haecker holds that from his experience at the Minnesota Station (U.S.A.) with dairy cows, the food required should vary with the quality of the milk as well as with the quantity. Assuming that the Kellner standard above is for milk containing 3 per cent. butter fat, Haecker suggests that a 1000 lb. cow giving "4 per cent" milk should have in addition 0·07 lb. digestible albuminoids and 0·466 lb. starch equivalent;[1] while for "5 per cent" milk, the addition required over "3 per cent." milk would be 0·11 lb. digestible albuminoids and 0·932 lb. starch equivalent.[2]

If one decided to vary the nutrient requirements in standard rations according to quality of milk given, it would be necessary to make these further additions to the total ration given above.

(5) The Armsby Feeding Standards.

Professor Armsby, of the Pennsylvania Experiment Station, has built up a system, very much on the lines of Kellner; except that the net energy (Thermal) value is substituted for that of starch equivalent. This net energy value means the energy which is actually

[1] Actually 0·4 lb. digestible carbohydrates and 0·03 lb. digestible fat.

[2] Actually 0·8 lb. digestible carbohydrates and 0·06 lb. digestible fat.

The starch equivalents have been calculated from these figures, in order to fit in with the Kellner standards.

available to the animal after deducting what is required for purposes of mastication, digestion, and assimilation.

How Energy Values are Obtained.—The energy or heat value of a food is obtained by the use of a calorimeter,[1] which is in physics an apparatus in which a given quantity of a food is burned in oxygen gas under pressure. The amount of heat evolved is taken up by water, and the increase in temperature noted by a thermometer.

For this purpose, the heat value of the food is measured, by adopting a unit called a "calorie," which is the amount of heat required to raise 1 kilogram (2·2 lbs.) of water 1° C., or 1 lb. of water 4° F. "Therm" is the name given to 1000 calories, as this unit is found to be more convenient for nutrition studies.

The "total" heat value (energy) obtained by the use of the calorimeter with 100 lbs of the following foods were as follows:—

Timothy hay (15 per cent. moisture)	175·1	therms
Oat straw („ „)	171·0	„
Maize meal „ „	170·9	„
Pure digestible albuminoids	186·0	„
„ „ carbohydrates	186·0	„
„ „ fat or oil	422·0	„

It will be noticed that fat has a value of 2·27 times that of the carbohydrates, which is very near the commonly accepted average figure of 2·3.

The "available" energy to the animal is that which remains after deducting from the total in the food that found in the excrements, as well as that which escapes from the body in the form of gas. The deductions to be made in this way amounted to 22·4 per cent. in the case of maize meal, and 56·8 per cent. in the case of timothy hay.

[1] A calorimeter is now installed at the School of Agriculture, Cambridge, for use in nutrition studies with farm animals.

The "net energy" value of the food is obtained by deducting from the "available energy" that part which is used up for purposes of mastication, digestion, and assimilation. In the case of maize meal, this deduction amounted to 36·3 per cent. of the "total energy" value of the food, and with timothy hay 29 5 per cent.

The total losses in these two cases amounted to 58·7 per cent. in the case of maize meal, and 85·3 per cent. with timothy hay, leaving "net energy values" for maintenance and production purposes of 41 3 per cent. and 14 7 per cent. respectively, or in thermal units, as 70·7 and 26 4 therms respectively.

In this way Armsby was able to arrive at the "net" energy values of the various feeding stuffs, a few of which are given below. The figures are per 100 lbs. of the particular food:—

Feeding Stuff	Total Dry Matter	Digestible Albuminoids	Net Energy Values
	lbs.	lbs.	therms
Decorticated cotton cake	91·8	35 15	84 20
Linseed cake	90·8	27·54	78·92
Wheat (grain)	89 5	8·90	82·63
Barley („)	89 1	8 37	80·75
Maize („)	89 1	6 79	88·84
Oats („)	89·0	8 36	66·27
Dried brewers' grains	92·0	19·04	60·01
Wheat bran	88 1	10·21	48·23
Wheat middlings	84·0	12 79	77·65
Red clover hay	84·7	5 41	34·74
Timothy hay	86·8	2·05	33·56
Lucerne (green)	28·2	2·50	12·45
Red clover (green)	29 2	2·19	16·17
Rye (green)	23·4	1 44	11·63
Mangels	9 1	0 14	4·62
Swedes	11·4	0·88	8·00

Armsby Feeding Standards for Cattle.—These are divided into two parts: (1) the maintenance requirements, and (2) the production requirements.

Maintenance.—This is assumed to be the same whether the animal is a cow or a steer.

Live Weight.	Digestible Albuminoids.	Energy Value.
500 lbs.	0·30 lb.	3·80 therms.
750 „	0·40 „	4·95 „
1000 „	0·50 „	6·00 „
1250 „	0·60 „	7·00 „
1500 „	0·65 „	7·90 „

Production.—The daily production standards are given per 1 lb. of increase in the case of a fattening bullock and per 1 lb. milk (4 per cent.) given in the case of a milking cow.

Mature Fattening Cattle.	Milking Cows.
3·5 therms per day for each 1 lb. increase in live weight.	0·05 lb. digestible albuminoids and 0·3 therm per day for each 1 lb. of 4 per cent. milk given.

Total Rations required.—The total ration required by a 12 cwt. cow giving 40 lbs. of milk, would be as follows:—

Live Weight.	Digestible Albuminoids.	Energy Value.
For maintenance, 1344 lbs.	0·62 lb.	7·36 therms.
For production, 40 lbs. of milk	2·00 „	12·00 „
Total daily ration	2·62 lbs.	19·36 therms.

In the case of a fattening bullock, increasing at the rate of 2 lbs. per day, the total daily ration required for a bullock (say 1000 lbs. live weight) would be:—

	Digestible Albuminoids.	Energy Value
For maintenance	0·50 lb.	6·00 therms.
For production, 2 lbs. per day	...	7·00 "
	0·50 lb.	13·00 therms.

Armsby Standards for Horses and Sheep.—The food standard for a horse, 1000 lbs. live weight, consists of 1 lb. digestible albuminoids and an energy value of 7 therms; whereas for a sheep, 100 lbs. live weight, the total daily ration should contain 0·10 lb. digestible albuminoids and an energy value of 1·0 therm.

If one refers to the table on p. 135, it is now quite easy to make up suitable rations to a particular food standard by this method.

XVIII. VALUATION OF FOODS.[1]

It is very difficult to devise a satisfactory method of valuing foods, seeing that they vary so much in composition and digestibility. The value of the food to the animal must be taken in conjunction with the value of the manurial residue, if its real value is to be obtained. Even when all these are taken into account, and the food valued accurately from its chemical constituents, there are such important things as palatability, laxativeness, etc., for which it is difficult to fix a proper value.

The "Food Unit" system values the food from its chemical composition alone, without considering its digestibility; while the second system takes into con-

[1] In this section the cost of feeding stuffs, for summer 1924, will need to be increased approximately 50 per cent., and the unit values by the same amount.

sideration the food which is retained by the animal body, and makes allowance for the manurial residue.

(a) Food Unit System.—The method employed in obtaining the number of "food units" in a food, is by multiplying the actual percentage of albuminoids and oil by $2\frac{1}{2}$, and adding these results to the percentage of carbohydrates. The total then represents the number of food units in the food. *E.g.*, linseed cake contains: albuminoids, 30 per cent.; oil, 10 per cent.; carbohydrates, 34 per cent. Hence:—

$$30 \times 2\frac{1}{2} + 10 \times 2\frac{1}{2} + 34 = \text{Food units in linseed cake.}$$
$$75 + 25 + 34 = \quad " \quad "$$
$$134 = \quad " \quad "$$

The "value of a food unit," or the "unit value," is obtained by dividing the price per ton by the number of food units in the food. *E.g.*, suppose the above linseed cake could be bought for £9[1] per ton, the unit value would be $\frac{£9}{134} = \frac{180s.}{134} = 1s.\ 4d.$

One could now value approximately and compare other linseed cakes by ascertaining the food units they contain and multiplying this number by 1s. 4d.

This system may also be used for valuing and comparing foods of a similar nature and composition; decorticated cake and soya bean cake.

	Albuminoids		Oil		Carbohydrates.		Food units.
Decorticated cotton cake .	$41 \times 2\frac{1}{2}$	+	$9 \times 2\frac{1}{2}$	+	26	=	151
Soya bean cake . . .	$43 \times 2\frac{1}{2}$	+	$7 \times 2\frac{1}{2}$	+	27	=	152

The food units in these two foods are practically equal, and unless the units in one case are more valuable than

[1] The price of linseed cake is now (summer 1924) about £13, 10s. per ton and the unit value 2s.

those in the other, the cakes would be of equal value. The unit value of decorticated cotton cake is approximately 1s. 2d., that is, 2d. less than for linseed cake, which shows that a level "unit value" for all concentrated foods is not feasible.

Further, foods rich in fibre require much more energy for digestion, and are consequently less valuable per food unit for feeding purposes.

A rough idea of *whether any particular food is cheap or dear at present market prices* may be obtained by putting money values on the albuminoids, oil, and carbohydrates[1] respectively guaranteed in the food under consideration; but for this purpose it is necessary to divide concentrated foods into two groups, according to their fibre content, viz.:—

Group I. Those containing less than 12 per cent. fibre (except those with over 40 per cent. albuminoids).

Group II. Those containing over 12 per cent. fibre (including those with over 40 per cent. albuminoids).

Then by allowing the following unit values[2] (which, by the way, may vary from year to year), viz.:—

	Albuminoids.	Oil.	Carbohydrates.
I.	3s. 3d.	3s. 3d.	1s. 3d.
II.	2s. 9d.	2s. 9d.	1s. 1d.

the estimated value per ton will be obtained.

[1] The percentage of carbohydrates is not stated on an invoice, and an average analysis for the food in question will need to be taken from the average analysis given on pp. 48 to 51.

[2] These prices are for autumn of 1914. Taking the summer prices of 1924, these unit values will need to be increased by approximately 50 per cent.

The following examples will show how to apply this method with, say, linseed cake, oatmeal, decorticated cotton cake, and dried brewers' grains:—

Group I.		Linseed Cake.		Oatmeal.
Albuminoids .	30	at 3/3 = £4 17 6	15	at 3/3 = £2 8 9
Oil . . .	10	at 3/3 = 1 12 6	8	at 3/3 = 1 6 0
Carbohydrates	34	at 1/3 = 2 2 6	60	at 1/3 = 3 15 0
Prices per ton .		£8 12 6		£7 9 9

Group II.		Decorticated Cotton Cake.		Dried Grains.
Albuminoids .	41	at 2/9 = £5 12 9	20	at 2/9 = £2 15 0
Oil . . .	9	at 2/9 = 1 4 9	7	at 2/9 = 0 19 3
Carbohydrates	26	at 1/1 = 1 8 2	42	at 1/1 = 2 5 6
Prices per ton .		£8 5 8		£5 19 9

When the market price is in excess of the estimated value the food is generally dear, when below, it is cheap, provided the condition is good and it is suitably blended. It will be noticed that this system does not take any notice of the palatability of a food, and only indirectly the digestibility, but includes manurial value.

(*b*) **Manurial Residue**.—The undigested part of the food, known as the solid excrement, is fairly rich in nitrogen, phosphates, and potash, consequently it has considerable value as a manure for farm crops. Further, the digested part is only partially retained by the animal body, which makes the liquid excrement rich in nitrogen and potash.

These residues have been valued by Hall and Voelcker in the following table (see pp. 142-44). In practice the full theoretical manurial value of the residue is not realised, on account of leakage, which is, even with the greatest care, considerable, and in other cases enormous. An allowance has been made in the last column of the table for leakage of manurial constituents,

but it is necessary that precautions should be taken to have an impervious floor, to prevent washing by rain as well as heating of the manure, if these manurial values are to be realised.

The net cost of the food for feeding purposes is therefore the total cost per ton, less the value of the residue actually retained in the manure.

XIX. PREPARING FOODS FOR STOCK.

Several devices have to be adopted by the feeder of stock to overcome difficulties which arise in his efforts to supply the stock with a wholesome, palatable, and at the same time economical ration. Some of these are as follows —

1. Drying, or Haymaking.—Green foods like grasses and clovers are made into hay *i.e.* dried in air, after which, with ordinary care, they will keep sweet for one or more years.

In England it is usual to cut the grass, turn it and possibly ted it, till sufficiently dry. A side-delivery rake places it in a row, from which it is made into small heaps called "cocks," containing ½ to 1 cwt. each. After a few days it is carted and made into a stack, the whole operation being concluded in a week or a fortnight, according to the weather.

In Scotland as soon as the grass is turned and approximately air-dried, although too green to cart it is placed in large heaps or "tramp coils" in the field, each containing 10 to 20 cwts. of hay. In wet districts a "boss" is placed in the middle to facilitate drying. After one or two months it is carted and stacked.

The chief difference, although not constant, is that English hay "sweats" a little, and becomes a nice

Manurial Values of Various Farm Foods of Average Quality.

Compiled by Dr Charles Crowther, The University, Leeds.

MANURIAL INGREDIENTS.

Food	Per Ton: Nitrogen (N)	Per Ton: Phosphoric Acid (P$_2$O$_5$)	Per Ton: Potash (K$_2$O)	Per Ton: Lime (CaO)	Per Cent: Nitrogen	Per Cent: Phosphoric Acid (P$_2$O$_5$)	Per Cent: Potash (K$_2$O)	Per Cent: Lime (CaO)	Estimated Value of Manure produced by Consumption of One Ton of the Food (allowing half the Nitrogen, three-quarters of the Phosphoric Acid, and the whole of the Potash). (Hall & Voelcker's Method.)
	lbs	lbs	lbs	lbs	per cent	per cent	per cent	per cent	£ s. d.
Cotton-seed Cake—									
Decorticated	155	70	36	7	6·9	3·1	1·6	0·3	2 14 10
Undecorticated	80	56	36	7	3·6	2·5	1·6	·3	1 13 7
Linseed Cake	106	38	29	9	4·7	1·7	1·3	·4	1 17 3
Rape Cake	112	45	29	15	5·0	2·0	1·3	·7	1 19 8
Earth-nut Cake	168	29	33	4	7·5	1·3	1·5	·2	2 14 0
Cocoa-nut Cake	76	33	44	11	3·4	1·5	2·0	·5	1 11 10
Palm-nut Cake	58	24	11	7	2·6	1·1	·5	·3	1 0 1
Soya Bean Cake (Soya Cake)	154	49	40	6	6·9	2·2	1·8	·3	2 13 6
Soya Beans	128	22	29	4	5·7	1·0	1·3	·2	2 1 8
Linseed	86	32	24	7	3·6	1·4	1·1	·3	1 9 2
Locust Beans	23	11	15	7	1·0	·5	·7	[illegible]	0 9 11
Wheat Middlings (Fine Pollards)	54	31	18	1	2·4	1·4	·8	·05	1 0 9

Wheat Sharps (Coarse Pollards)	56	58	31	2	2·5	2·6	1·4	·1	1	6	6
Wheat Bran *	54	60	33	4	2·4	2·7	1·5	·2	1	6	6
Oatmeal	54	54	33	2	2·4	2·4	1·5	·1	1	5	10
Gluten Meal	136	7	1	1	6·1	·3	·05	·05	1	17	6
Gluten Feed	94	15	4	2	4·2	·7	·2	·1	1	7	7
Rice Meal	42	56	15	2	1·9	2·5	·7	·1	0	19	10
Malt	38	18	11	2	1·7	·8	·5	·1	0	14	0
Malt Dust, or Coombs	85	40	45	4	3·8	1·8	2·0	·2	1	14	11
Brewers' Grains (Wet)	18	9	1	2	·8	·4	·05	·1	0	5	11
Brewers' Grains (Dried)	67	36	4	9	3·0	1·6	·2	·4	1	2	5
Molasses	33	1	56	7	1·5	·05	2·5	·3	0	19	1
Meat Meal	257	15	2	9	11·5	·7	·1	·4	3	11	0
Wheat	40	20	13	1	1·8	·9	·6	·05	0	15	2
Barley	36	18	13	1	1·6	·8	·6	·05	0	13	10
Oats	43	15	11	2	1·9	·7	·5	·1	0	15	0
Rye	40	20	13	1	1·8	·9	·6	·05	0	15	2
Maize	38	13	9	1	1·7	·6	·4	·05	0	13	2
Beans	90	27	29	2	4·0	1·2	1·3	·1	1	11	11
Peas	81	20	22	2	3·6	·9	1·0	·1	1	7	7
Straw—Wheat	10	4	18	4	·45	·2	·8	·2	0	6	4
Barley	11	4	24	7	·5	·2	1·1	·3	0	7	10
Oat	11	4	33	9	·5	·2	1·5	·4	0	9	6
Rye	10	4	20	6	·45	·2	·9	·3	0	6	9
Bean	29	7	42	27	1·3	·3	1·9	1·2	0	16	1
Pea	31	9	22	36	1·4	·4	1·0	1·6	0	13	4
Meadow Hay	34	9	36	22	1·5	·4	1·6	1·0	0	16	4
Clover Hay	50	13	40	44	2·2	·6	1·8	2·0	1	1	8

* To get approximately the equivalent amounts of Ammonia, increase by one-fifth.
† To get approximately the equivalent amounts of Phosphate of Lime, multiply by 2½.
‡ In calculating these manurial values the unit prices adopted by Hall and Voelcker (*Journal of the Royal Agricultural Society*, vol. lxiii., 1902, p. 100) have been employed, viz.:—

NITROGEN = 12/- (= Ammonia at 9 10½)
PHOSPHORIC ACID = 3/- (= Phosphate of Lime at 1/4½)
POTASH = 4/-.

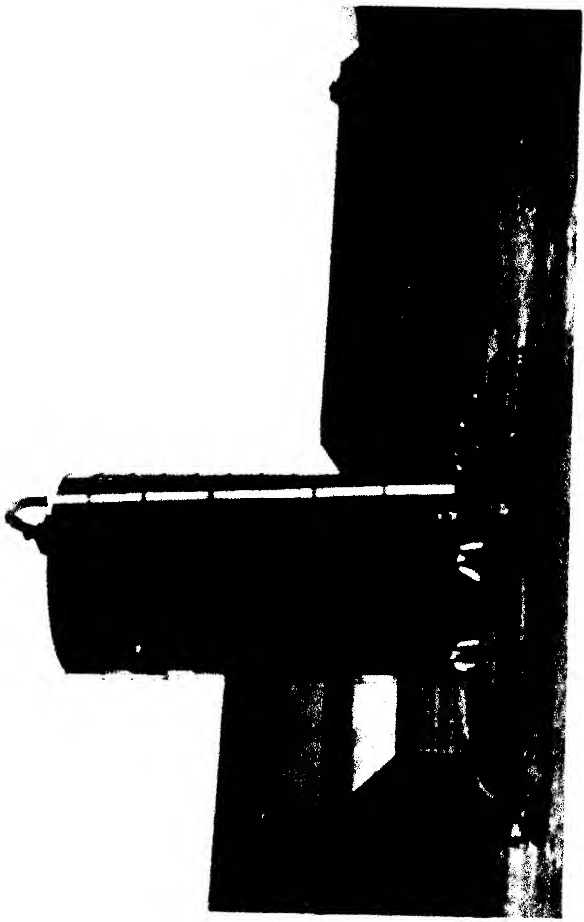
Lime is not taken into account.

Manurial Values of Various Farm Foods—*continued.*

FOOD	MANURIAL INGREDIENTS. Per Ton. Nitrogen (N).	Per Ton. Phosphoric Acid † (P_2O_5).	Per Ton. Potash (K_2O).	Per Ton. Lime (CaO).	Per Cwt. Nitrogen *	Per Cwt. Phosphoric Acid † (P_2O_5).	Per Cwt. Potash (K_2O).	Per Cwt. Lime (CaO).	Estimated Value of Manure produced by Consumption of One Ton of the Food (allowing half the Nitrogen, three-quarters of the Phosphoric Acid, and the whole of the Potash). (Hall & Voelcker's Method.) ‡ £ s. d.
	lbs.	lbs.	lbs.	lbs.	per cent.	per cent.	per cent.	per cent.	£ s. d.
Pasture Grass	11	3	13	9	·5	·15	·6	·4	0 5 9
Clover (Green)	13	3	11	11	·55	·15	·5	·5	0 5 8
Vetches (Green)	13	3	11	11	·55	·15	·5	·5	0 5 8
Lucerne (Green)	14	3	9	20	·65	·15	·4	·9	0 5 11
Cabbage	10	3	9	4	·4	·15	·4	·2	0 4 4
Rape	10	3	7	4	·45	·15	·3	·2	0 4 3
Turnip Tops	8	3	4	9	·35	·15	·2	·4	0 3 3
Turnips	4	2	7	1	·2	·1	·3	·05	0 2 7
Swedes	4	2	7	2	·2	·1	·3	·1	0 2 8
Mangels	4	2	11	1	·2	·1	·5	·05	0 3 5
Carrots	4	2	7	3	·2	·1	·3	·1	0 2 7
Sugar Beet	4	2	9	1	·2	·1	·4	·05	0 3 0
Potatoes	7	3	13	1	·3	·15	·6	·05	0 4 6
Cow's Milk—Whole	...	...	...	...	·55	·2	·15	·15	...
Skim or Separated	...	...	...	...	·5	·2	·2	·15	...
Whey	...	...	...	...	·15	·1	·15	·2	...

* See (*) p. 148. † See (†) p. 148. ‡ See (‡) p. 148.

PLATE XIV.



brownish yellow colour, while the Scotch hay retains, more or less, its natural colour.

2. Silage.—Occasionally in Great Britain the weather is very wet at haymaking time, and any hope of getting the grass dried with the sun may seem, at the moment, remote. In such a case, the grass may be cut and carted at once into a stack, clamp, pit or Tower silo. The grass settles down very considerably, and becomes dark brown in colour, with a very strong smell. It is then called silage. Stock, however, eat it, and it is being used to substitute the whole or a part of the roots. Although grass may be preserved in this way, it is better, where possible, to make it into hay.

In America, green maize is chaffed and blown into a tall cylindrical building (silo). It is simply trodden down with a couple of men, and will then keep for two years or even more. This silage has a much nicer appearance than silage usually made from grass in Great Britain. In the author's opinion, the only satisfactory method of dealing with forage crops grown systematically for dairy cows (*i.e.*, arable dairy farming) is to use a Tower silo, and convert them into silage.

3. Chaffing.—This term is applied to the cutting of hay and straw into very short lengths by machinery. The resulting chaff or chop is most useful for mixing with pulped roots and concentrated foods. In this way the hay and straw go much further, largely because there is less wasted from the rack or "cratch." Hay of rather inferior quality can be gradually worked off in this way.

For fattening animals the mechanical energy demanded from the body to chew, masticate, and pass these bulky foods along the alimentary canal is minimised when the hay and straw have been chaffed

in this way. The same thing applies to grinding concentrated foods.

4. **Pulping, fingering, and slicing Roots.**—For young stock as well as for mixing with chaffed hay and straw, the roots must be reduced to small pieces by machinery. Pulping cuts the roots into very small pieces, while fingering cuts the roots into pieces like human fingers. Slicing means cutting the roots into parallel slices of, say, half-inch in thickness. Pulped roots are chiefly used for mixing with chaffed hay and straw; fingered roots, although sometimes fed with chaff, are largely used for sheep; while sliced roots are fed to cattle which are unable, on account of teething changes, to eat or "break" whole roots.

5. **Grinding, Rolling, and Nutting.**—These terms refer to different methods of bruising seeds, grain, or cakes. Grinding reduces the food to a meal, while rolling simply squeezes it out flat. Meal is preferable for feeding with chaffed hay and straw. Rolled oats are better fed to horses in the dry state.

Cakes may be ground down to a meal, or may be broken into small pieces or "nuts." In the latter case the cake is said to be "nutted." Some cake manufacturers are making the cake into cakettes, and in a few cases small "nuts" or cubes of one inch each side; the great advantage being that it dispenses with nutting the cakes on the farm.

6. **Softening Coarse Foods.**—Coarse, hard concentrates like undecorticated cotton cakes should be nutted for a week or a fortnight before being fed to stock, as the nutted cake absorbs moisture from the air and becomes very much softer. Apart from this, nails may sometimes be detected and removed before feeding.

Hay and straw chop, wheat chaff, and oat chaff may

be mixed with pulped roots, and possibly water added. The mass is left for at least half a day to enable the moist roots and water to soften the coarse straw, and later bring about slight fermentation, so as to make the ration more attractive to stock.

Inferior foods are often used up in this way, the food being made attractive with treacle, locust-bean meal, or other condimental foods (see p. 81).

7. Steeping.—Many folks believe that if concentrated foods are steeped in water and fed to milking cows in the form of a thick gruel or "crowdy," that the yield of milk will be increased. This may be the result for a short time after the commencement, but experiments at Offerton Hall, County Durham, do not show that this method of preparing the food is justified by results.

It is not advisable to give either wheat or barley in the raw state to horses; in fact, wheat is often blamed for giving horses "fever of the feet" (laminitis). If, however, these foods have been previously steeped, they can be fed to horses as part of the ration without much fear.

For calves the gruel fed to them may be made by steeping the meals in cold water for half a day before feeding, instead of scalding it and feeding almost immediately.

8. Cooking or Steaming.—This is applied to foods which have either been steamed or treated with hot water. It has the effect of softening the food, and often improving the palatability. Experiments do not appear to show that cooked food is more digestible than uncooked, although it may be more readily eaten by stock.

With horses, foods which have been boiled (beans, barley, linseed) or treated with boiling water and made

into a mash (bran), are used in the winter months to facilitate the casting of the coat. The same foods may be used as occasional laxatives.

For pigs, potatoes may be boiled or steamed and mashed up with meals, so as to make an attractive feed.

Cake manufacturers generally cook or steam the foods before they press them into cakes for cattle feeding. Calf meals are often made into gruels with boiling water before being served to young calves; those calf meals containing ground linseed cake should be moistened and stirred with a little cold water before adding boiling water, otherwise the gruel is apt to form into lumps and the inside of the lumps remain uncooked.

9. **Warming foods** in cold weather may have a rather considerable effect, seeing that all cold food taken into the system must be heated up to the temperature of the body at the expense of the food; further, the effect of a sudden chill on the system of stock generally does not tend to improve the health. There appears to be ground for believing that in cooked foods or gruels fed warm, any benefit derived is more due to their being fed warm than to the actual cooking.

10. **Condiments.**—These are generally vegetable substances which give flavour and often aroma to unpalatable foods, thus making them acceptable to stock. Appetising foods appear to increase the flow of the digestive juices, and encourage stock to eat a larger quantity than they would otherwise do. In fattening cattle this is very important, since, generally speaking and within certain limits, the more food the animal can be induced to eat, the quicker it will fatten, and some saving will have been effected on the food, more especially with regard to the maintaining of

the body temperature at approximately 40° F. above atmospheric temperature for a shorter period than would otherwise have been the case.

In the case of horses doing hard work, they may not eat a sufficient quantity of unattractive foods to enable them to perform their daily work, consequently they lose flesh, but with the addition of some condimental food they may often be induced to eat sufficient food each day to keep them fit and trim for the work.

The same argument could be applied to young animals which are growing rapidly. Hence for rapid growth, fattening, and for work, even with concentrated but possibly tasteless or unpalatable foods, it is advisable and often necessary to add spices to the ration to make it more appetising.

With inferior foods, such as hay which has been weathered and probably gone slightly mouldy, it is very necessary to add spices or condiments to disguise the flavour. Theoretically such hay should not be fed, but in practice it is often necessary to use hay up in this way.

Condiments and condimental foods are only used in sufficient quantity to make the other concentrated foods attractive. They may consist of one substance, or a mixture from several sources; *e.g.*, broken (kibbled) locust beans, ground locust beans, malt coombs (cummins), treacle, and possibly oatmeal and oat hulls, are all single substances which are commonly used. Locust beans and treacle sweeten foods considerably, while cummins and oatmeal give a pleasant aroma.

Condimental mixtures may contain several ingredients which stimulate the flow of saliva and digestive juices, and to some extent purify the blood. The

following would be a fairly typical and cheap ½ cwt. mixture:—

Sulphur	4 lbs.
Saltpetre	4 „
Common salt	1 „
Fenugreek (powdered)	2 „
Gentian („)	1 „
Aniseed („)	1 „
Ginger („)	1 „
Locust-bean meal	14 „
Maize meal	28 „
	56 lbs.

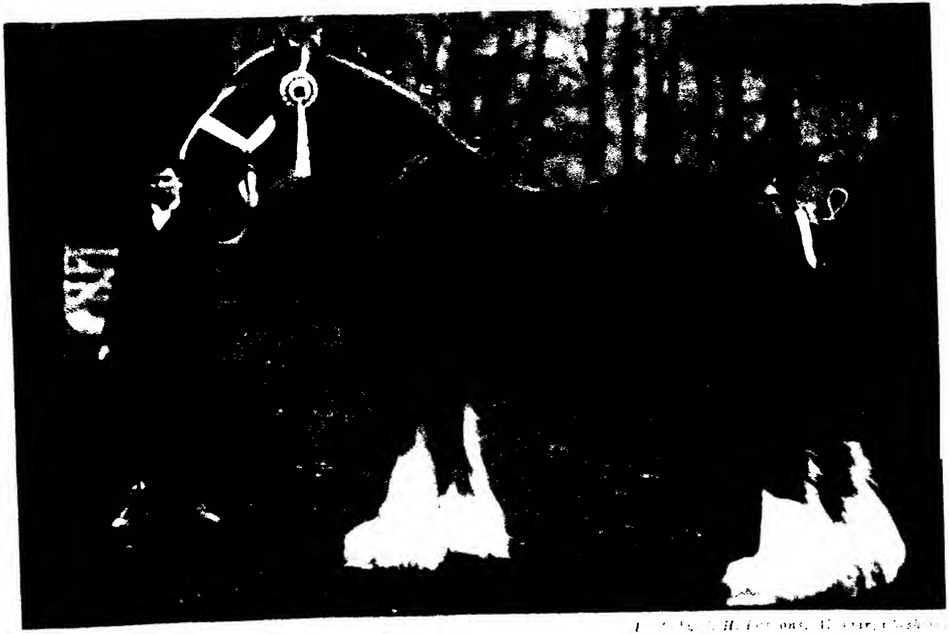
XX. FARM HORSES.

The type of draught horse which is at the same time most suitable for work and most valuable when the horse is to be sold, is one which possesses a good constitution, a big massive body, with sound legs and feet. The horse should have good action, clean flat bones, and its legs should be attached to the body and shaped in such a way as to stand severe work. In addition, horses affected with roaring, grunting, shivering, cribbing, and similar defects should be avoided.

Undoubtedly the breeding of the animal has a great part to play in securing an animal of this type, especially when one remembers that so many defects like sidebone, ringbone, shivering, etc., are hereditary; but what concerns us chiefly at this point is the feeding of horses from birth to maturity, in such a way as to secure size, substance, and avoid injuring the legs by careless feeding; in fact, muscular development in young horses is all-important.

Brood Mares.—It is usual to commence the mare

PLATE XV.



[illegible] H. [illegible]

A [illegible] Shire Mare, "Sir Walpole Gresswell" [illegible] Royal Show Champion.

breeding at about three years old, the period of gestation extending over eleven months.[1] Pregnant mares require plenty of fresh air and exercise, and a fairly liberal diet, which is sufficiently rich in albuminoids and bone-forming materials (phosphates and lime) to support and develop the fœtus. Cold spring water should not, generally speaking, be given to mares in foal, as well as any foods that are liable to produce flatulency or colic, *e.g.*, bean meal, raw potatoes, etc.

Unless the mare is out at grass at foaling time, she will require a fairly laxative diet, *e.g.*, bran mashes, etc., so as to get her bowels working fairly freely, and thus facilitate foaling. If the mare is to foal in a loose-box, it should have been previously cleaned out and disinfected, so as to free the walls and floors from the germs which are responsible for navel ill or joint felon; in fact, the navel should be disinfected and tied immediately after foaling with string which has been previously soaked in a disinfectant.

Grass is the natural food for milk, but if this is insufficient or not available, it will be necessary to gradually substitute the bran mashes at foaling time with other concentrated foods, which will increase the flow of milk, such as ground oats, maize meal, bran, bean meal, and linseed cake. Mangels, swedes, or forage crops (vetches, etc.) would be most useful along with some nice sweet hay. If roots are scarce, treacle may be used on the hay crop.

The Foal.—As soon as the foal is strong enough to stand up, it may be necessary to assist it in getting its first drink of milk. Shortly after this drink it is usual for the bowels to work.

If the foal is persistently costive, it would be necessary to give the mare a more laxative diet, *e.g.*,

bran mashes, roots, forage crops, etc., while in extreme cases the foal may be given a tablespoonful of castor oil.

Mare's milk is poor in albuminoids (2 per cent.) and fat (1¼ per cent.), but rich in sugar (5½ per cent.), hence for orphan foals cow's milk may be used, provided it is made to approximate to the composition of mare's milk. This can be done by taking two-thirds cow's milk and one-third water, adding one or two teaspoonfuls of sugar for every pint of the mixture of milk and water.

In Norfolk, after foals are two weeks old they are sometimes fed in addition to their mother's milk with skim milk, boiled linseed, and bean meal, getting by weaning time (six months old) probably as much as 2 galls. milk and 3 to 4 lbs. mixed meals per day.

The Young Horse.—The great thing to keep in mind at this time is to encourage the production of hard flat bone, sound legs and feet; but if the foal is kept in close boxes, standing on heating manure and liberally fed, there is great danger that this ideal will not be realised. Without doubt the best way is to leave the young horses out in the fields altogether, provided they can run into a shed at will when the weather is bad, as well as to receive their daily supply of hay, cake, and corn. There is no finer concentrated food for young stock than a mixture of 3 parts crushed oats, 2 parts bran, and 1 part linseed cake, given at the rate of 1 to 2 lbs. per 100 lbs. live weight. With this open-air life the young horses get plenty of exercise. Every effort should be made to expand the heels of the young horse's feet and develop the frog. To do this, it is necessary to bring the frog in contact with the ground,

PLATE XVI.

so that the pressure on the frog will tend to expand the heels. Careful shoeing is most important when the young horse is old enough to have shoes on. If the shoe is hinged at the toe, so as to move laterally at the heels, it will encourage the heels to expand. The concentrated part of the ration should be rich in albuminoids, so as to develop as much as possible the muscular part of the young horse. The horse would be ready for work at about two to three years of age.

Work-Horses.—Generally speaking, the ration of horses doing fast work should be richer in albuminoids and less bulky than that which would be required for those doing slow work. When the horses are not at work the quantity of concentrated food given may be considerably diminished. Inferior foods should only be fed in small quantities at a time, along with comparatively large quantities of wholesome foods, and changes of diet should always be made gradually.

It will now be helpful, in compounding rations for horses, to discuss the various suitable foods and the particular form in which these should be fed.

Hay and Straw.—Horses much prefer the stronger stemmed grasses (rye grasses and timothy, etc.), and clovers when made into hay, than the softer meadow hay. Old meadow hay, however, is preferred by some for hunters.

New hay which is heating (*i.e.* in the sweat) should not be fed to horses at all, if it can be avoided, otherwise it is almost sure to cause their legs to swell. Hay which has been heavily manured with nitrate of soda adversely affects the kidneys.

Horses receiving straw as well as hay are considered to "keep better in their wind," and stand hard

work better than those fed on hay alone. The cost of long food can therefore be somewhat cheapened by including straw.

If the hay and straw are chaffed and mixed with meals, they can be made to go further, partly because less is wasted. Inferior hay may be spiced, so as to get the horses to eat it readily.

Oats.—New oats should be carefully fed, as they have a tendency to make horses' legs swell. Young horses and "bolters" should have oats crushed or rolled, in order that they may digest them better. The former have difficulty in grinding whole oats during the time their teething changes are taking place. Bruised oats are more economical to feed than whole oats, due partly to men feeding them chiefly by measure. It is a very wasteful plan to give a horse more than it can clean up each time. The feed of oats should not be given immediately before watering, otherwise the coarse hulls may be washed into the bowels, thus causing irritation and colic.

It is usually considered that horses which grind down whole oats and fodder crops for themselves stand severe work better than those receiving bruised oats along with chaffed hay and straw.

Barley.—Not very suitable; should not be fed unless steeped or boiled.

Wheat.—Must be fed with caution, as it is so often blamed for giving horses fever of the feet (laminitis).

Peas and Beans.—These foods are rich in albuminoids, consequently they have the power of developing and strengthening the muscles, which is all-important for horses doing hard work. For fast work they are especially useful, and their poverty in fat makes them all the more suitable for this purpose.

They may be included in the ration to the extent of 2 to 3 lbs. per day, but horses receiving them should be regularly exercised if not at work, otherwise they may become too lively.

Bean meal is a rather sticky food when moistened with water, and needs to be mixed with crop or bulky concentrates like bran or dried grains, to open it up. If fed in too large quantities it may cause flatulency or colic.

Maize.—A useful food, but is very heating on account of its comparative richness in fat (5 per cent.), and should not be fed alone. It is best used in combination with oats, bran, peas, beans, or dried grains, up to 6 lbs. per day. For slow work the proportion of maize in the mixture should be higher than for fast work. It is either fed as a meal or cracked.

Bran.—This bulky concentrate is extremely useful for mixing with bean meal, maize, oats, etc.

When made into a mash with hot water it has a laxative effect, and it is a common practice on some farms to give horses bran mashes at week ends. This is useful, especially when the horses have had high feeding through the week. It is not wise to mix ground oats with a bran mash and feed at once, as the mash travels through the system comparatively quickly and may carry some of the rough hulls of the oats into the bowels before they have got properly softened, possibly causing colic. Boiled linseed, boiled beans, or boiled barley may be used in the same way as bran mashes, especially at times when the horse is casting its coat.

Some of the best farmers have ceased to give horses mashes at week ends, as they consider it better to give them two to three tablespoonfuls per head daily of linseed oil on the chop food. In this way there is less

risk than when the horse receives big doses of the laxative food (bran mashes) at week ends only.

Roots.—Roots are very useful for keeping the bowels in working order. Carrots are the most suitable roots for horses, next come swedes. Potatoes are apt to cause colic (flatulency) unless carefully and sparingly fed. It is best to feed roots regularly to work-horses to the extent of 3 to 10 lbs. per head per day.

Suitable Rations for Horses.

The table shows typical daily rations of concentrated foods[1] for farm-work horses which weigh on

	Daily Ration of Concentrated Food.	Average Composition of Mixture.		
		Albuminoids	Fat.	Fibre.
		per cent.	per cent.	per cent.
1	8 lbs. oats . . 2 lbs. maize . . 2 lbs. beans . .	14	5	8
2	8 lbs. maize . . 2 lbs. bran . . . 2 lbs. gram . .	13½	4½	4
3	6 lbs. maize . . 2 lbs. beans . . 3 lbs. dried grains . 1 lb. sharps . .	15¾	5	7
4	2 lbs. oats . . 2 lbs. sharps . . 4 lbs. maize . . 2 lbs. bran . . 2 lbs. gram . .	13½	5	6¼

an average between 1200 and 1300 lbs. each, keeping in mind the following "standard" with concentrated

[1] Farmers wishing to make up similar rations of concentrated foods should refer to special table of analyses on p. 206.

food: *albuminoids*, 12 to 16 per cent.; *fat*, 4 to 5 per cent.; *fibre* (not exceeding), 8* per cent.; and allowing 1 lb. concentrated food for every 100 lbs. live weight of horse.

Ration 2 is very low in fibre, and would be very suitable for feeding to horses receiving liberal allowances of oat straw in the long food. Ration 4 would do very well when horses were getting hay and straw. Linseed cake or linseed oil or roots may be added as required, to make the ration sufficiently laxative.

"Short" *v.* "Long" Feeding.

The question is often asked whether it is worth while to chaff the hay and bruise the corn for horses. It is now generally admitted that it is much more economical to adopt the "short feeding" method; but in the case of horses which can deal with their food in the whole state, they will stand hard work better than those receiving chaffed hay and bruised grain. The two examples given below will show the economy of "short" feeding.

(*a*) The London Tramway Company* had at one time 6000 horses. These were divided into two lots of 3000 each. Lot I. received crushed oats, hay, and straw chop, while Lot II. had their food in the natural state. The horses in each lot were doing the same class of work, and in spite of Lot II. getting a heavier ration, the advantage was with Lot I.; *e.g.*—

Ration, Lot I.	*Ration, Lot II.*
16 lbs. crushed oats.	19 lbs. whole oats.
7½ „ chopped hay.	13 „ long hay.
2½ „ cut straw.	

It was found that the "short" ration saved £60 per day on 3000 horses over that fed in the natural state. The total saving for the year on 6000 head was £22,300, making an average saving of £4, 7s. 8d. per head in favour of "short feeding."

(*b*) Messrs Stirling Bros., Darlingfield, Kelso, kept careful records of the amount of food consumed by five pairs of farm-work horses for two consecutive years. During the first year the hay was fed in the long state, and the grain unbruised; while for the second year the hay was chopped and the grain bruised. The quality of concentrated food given per day varied in both cases with the work done; *e.g.*, for the ordinary farm work, three feeds were given per day, during very busy times four feeds, while on Sundays only two feeds per day were given.

During the three summer months each year when the horses were out at grass, they received very little corn, hence the following average daily rations are only for forty weeks of the year, and have in fact been calculated from the bulk quantities used each year:—

Whole Feed (*1st Year*).	*Chop Feed* (*2nd Year*).
22 lbs. oats (whole).	18 lbs. crushed oats.
18 lbs. hay (long).	7 lbs. cut hay.
10 to 12 lbs. swedes.	10 to 12 lbs. swedes.
Wineglassful linseed oil.	Wineglassful linseed oil.
	2 lbs. beans during heavy work.
	Oat straw, *ad lib.*

The total quantities consumed in each of these years, disregarding the linseed oil and roots, which were the same in both cases, were as follows:—

170 qrs. oats (356 lbs. per qr.), at 18s. . . .	£153	140 qrs. oats, at 18s. per qr.	£126
22 tons hay, at £3 per ton	66	9 tons hay, at £3 . .	27
		1 ton beans, at £7, 10s.	7½
		Oat straw (estimated) .	15
		Power and extra labour.	5
	£219		£180½

The cost of food, therefore, was very approximately £40 per year less for the chop feed, which means an average saving for the year of nearly £4 per horse. Mr Stirling also adds that the horses kept their condition through the busy part of the year on the farm with the chop feed, but in previous years had always gone down in condition on the ration consisting of "long hay and whole oats."

(*c*) Mr George B. Shields, Dolphinston, near Edinburgh, considers that he saves considerably more than £4 per head per year through feeding the hay and straw cut and oats bruised. The proportions he used were 12 sacks of oats to 10 cwts. of hay and oat straw.

Watering.—The safest plan is to give water to horses before the feed of corn, as there is some danger of the unsoftened coarse hulls of oats or similar foods getting washed into the bowels, and there causing colic, if the horse is watered immediately after the feed of oats.

When it is inconvenient to give the water before the feed, watering should be delayed for, say, half an hour, so that the food may have time to soften and get acted on by the gastric juice in the stomach, before it is carried on into the bowels.

It is also very risky to give horses cold spring water when they come up very hot and tired; in fact, a large quantity of water at atmospheric temperature, which is much less risky, is scarcely advisable under these conditions, as it may give the horse colic through the sudden chilling of the system. A much safer plan is to give, say, half a pailful of water with the chill taken off, as soon as the horse comes up; then after it has had time to cool down, it may be allowed to have its fill of water.

Horses doing fast work, such as trotting or hunting, should have the quantity of water strictly limited before starting off, otherwise they will be burdened with the water, and perspire very freely.

Cost of Keeping a Farm-work Horse for a Year.

It is a very common thing to give horses simply oats for the concentrated feed for ordinary work, and to add beans for hard work, hence the following rations are taken:—

Summer Ration.—1st June to 31st August (thirteen weeks)—1 bus. oats per week, grazing on pasture, and cut green food in stable.

Winter Ration.—1st September to 31st May (thirty-nine weeks)—2 bus. oats, ½ bus. beans, 1 cwt. hay in addition to roots, per week.

Summer Cost for Thirteen Weeks—

13 bus. oats, at 2s. 6d.	£1 12 6	
13 weeks' grazing, at 2s.	1 6 0	
13 „ cut fodder, at 3s.	1 19 0	£4 17 6
Carried forward		£4 17 6

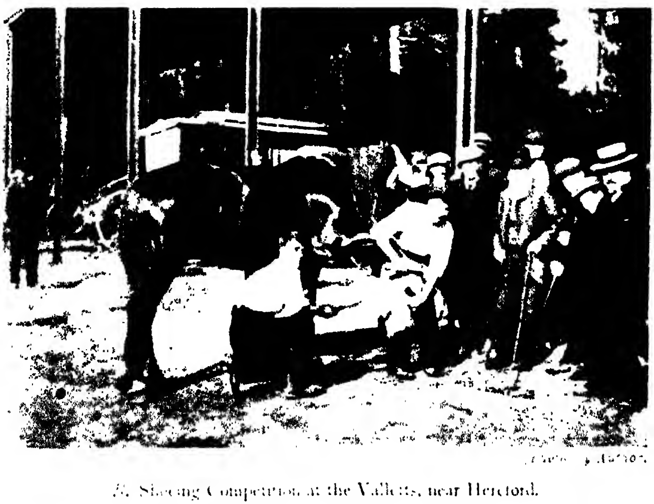


Photo by [illegible]

B. Shoeing Competition at the Vallets, near Hereford.

Good shoeing is as important as good feeding.

To face p. 160.

Brought forward		£4 17 6
Winter Cost for Thirty-nine Weeks—		
78 bus. oats, at 2s. 6d. . . .	£9 15 0	
9¾ „ beans, at 4s. . . .	1 19 0	
39 cwt. hay, at 3s. . . .	5 17 0	
Roots and condiments . . .	0 10 0	
		18 1 0
TOTAL COST OF FOOD PER YEAR . .		£22 18 6
Blacksmith, say 30s. per year . . .		1 10 0
Repairs to gears (saddler), say 20s. . .		1 0 0
Depreciation (very variable), say 50s. . .		2 10 0
Veterinary surgeon and risk, say 20s. . .		1 0 0
Interest, 5 per cent. on £40 capital . .		2 0 0
COST OF KEEPING HORSE PER YEAR		£30 18 6

It may be taken that the cost of keeping a pair of farm-work horses for a year is from £50 to £60. The farmer may put down £100 as being very approximately the cost of keeping a good waggoner or hind, and a pair of horses.

Score Card for Shire or Draught Horses.

The following "student's" score card was specially drawn up by the writer for use in the winter School of Agriculture of the Herefordshire County Council:—

[TABLE.

	Max. Points.
1. Height of horse at withers in hands (estimated)	...
2. Amount of bone on fore leg in inches (estimated)	...
3. Age, from its teeth, to nearest half-year	...
General Appearance, 20 *points*—	
4. POWERFUL—Broad and massive body, low set	6
5. ACTIVE—Action to be noticed walking as well as trotting	10
6. HEIGHT—according to age	4
Legs and Feet, 28 *points*—	
(*N.B.*—Unless an animal secures half maximum points for legs and feet, it need not be considered further.)	
7. FEET—Shape, size, and quality of horn	10
8. Quality of bone and feather	6
9. FORE PASTERNS AND JOINTS—up to elbows	6
10. HIND PASTERNS AND JOINTS—up to lower thigh	6
Head and Neck, 8 *points*—	
11. HEAD	4
12. NECK—Muscular, well-arched, fitting neatly on shoulders	4
Shoulders, 8 *points*—	
13. Long and sloping—fitting well on to the body	8
Body, 20 *points*—	
14. CHEST—Deep and wide, giving large heart-girth	5
15. RIBS—Long, and well-arched from back	5
16. BACK—Short and broad	5
17. LOIN—Broad and strong	5
Hind Quarters, 16 *points*—	
18. Long and Broad. Tail well set on	10
19. UPPER AND LOWER THIGHS—well developed	6
	100

The following points of a typical Shire horse are given to guide students in score-carding :—

Shire Horse.

* 1. *Height* of horse, about 17 hands.
2. *Bone*—About 11 inches below knee and 12 inches below hock.
3. *Age by Teeth*—Has full mouth of "temporary" teeth at two years and of "permanent" teeth at five years of age.

* The numbers to explanatory notes correspond to foregoing table.

Temporary incisors have a neck, and are whiter and smaller than the permanent incisors. Temporary incisors are cast about six months before the permanent teeth are full up and in wear. Horse "aged" after eight years old.

At about three years old, horse has "central" pair of permanent incisors up and in wear.

At about four years old, horse has "lateral" pair of permanent incisors up and in wear.

At about five years old, horse has "corner" pair of permanent incisors up and in wear.

At about six years old, the "mark" begins to disappear out of "central" pair.

At about seven years old, the "mark" begins to disappear out of "lateral" pair.

At about eight years old, the "mark" begins to disappear out of "corner" pair.

At eleven years old, Galvayne's groove appears on the side of the corner teeth, just below the gum.

At fifteen years, the groove has extended about half-way down the corner teeth.

At twenty years, this groove extends full length of corner teeth.

At twenty-five years, the groove is only seen on the lower half of the corner teeth, *i.e.*, it has grown half-way out.

At thirty years, the groove has practically disappeared.

4. *Powerful*—Indicated by broad, deep, and massive body on short, muscular legs.

5. *Action*—Straight and level—no rolling; good walker, with a bold and free trot.

6. *Size*—To be judged from age, as indicated by teeth.

7. *Feet*—Wide, open at heels, free from suspicion of flatness; horn of good quality.

8. *Bone and Feather*—*Bone*, clean and fat. *Hair*, luxuriant and silky, neither wiry nor woolly.

* The numbers to explanatory notes correspond to foregoing table.

*9. *Fore Legs*—Big and massive. *Pasterns*, sloping but not too long. *Knees*, squary and large. *Arms*, strong and muscular; tendons and ligaments well developed.

10. *Hind Legs*—As far as applicable same as fore legs. *Hocks*, should be big and bony; but clean, fairly close together when horse is standing, and especially so when trotting.

11. *Head*—Masculine appearance; intelligent. *Disposition*—Spirited.

12. *Neck*—Strong and muscular, well arched, sloping gradually on to shoulders.

13. *Shoulders*—Long and sloping; fitting well on to body.

14. *Chest*—Deep and wide, with good heart-girth.

15. *Ribs*—Should be long, and well arched from back.

16. *Back*—Short and broad.

17. *Loin*—Broad and strong.

18. *Hind Quarters*—Wide, long and massive. Tail well set on.

19. *Upper and Lower Thighs*—Well developed.

Shire Mare.

The mare generally differs from the horse in being smaller (about 16 hands), feminine in appearance, with docile disposition and placid temper.

Body should be slightly longer, to give room for foal.

Both mare and horse should be sound and possess a good constitution.

* The numbers to explanatory notes correspond to foregoing table.

XXI. FATTENING CALVES FOR VEAL.

Veal is the flesh of the young fat calf, and has long been a favourite article of diet. It is produced largely in the neighbourhood of big towns, and on this account is found to a much larger extent in England than in Scotland, where the number of large towns is comparatively small. Another important reason is that in Scotland, where so many young bullocks are fed off in cattle courts, there is a large demand for young calves which it is intended to fatten

off at about two years old, consequently prices are often given for calves a few days old, which will pay the breeder better than that obtainable after vealing them, especially if he has another important outlet for the milk. In fact, the conditions which determine whether calves should be vealed or not, are—*cheap calves*, *surplus milk*, and a *good price for veal.* With these conditions fulfilled, vealing can proceed either by allowing the calves to suck their dams or by hand-feeding.

(1) **The Natural Way.**—This consists in allowing the cow to suckle the calf, and it is thus that the finest quality of veal is produced. The calf is fed entirely on new milk, and obtains it direct from the cow in small quantities at a time, and as often as nature demands it. The suckled calf requires very little attention, and on this account the system is often adopted in practice. At first the newly born calf is unable to take all the milk, and the surplus will need to be removed. This may be done either by hand, or by allowing another bigger calf which is getting an insufficient supply for rapid fattening, to clean the udder out once or twice a day. With deep milkers, it may be necessary to give each cow a couple of calves from the beginning. These would have sufficient for the first few weeks, after which it might be necessary to remove one, or allow it periodically to suck another cow, in order to keep them both fattening rapidly. This system is not so suitable for cows which are kept for dairy purposes, as it unsettles them, and unless the cows are carefully stripped each day, the annual yield of milk will be considerably diminished.

(1) **Hand-feeding.**—This system is especially suited to dairy farms in spring, as there is often a surplus of

milk available at this time. The young calf can be given as much of its mother's milk as it requires, and that which remains may be given to other calves which need a little extra to bring them along rapidly. Dr Gillespie wrote a few years ago : " Hand-feeding requires skill, and above all careful management and unremitting personal superintendence. The person in charge must be thoroughly reliable, and very painstaking, and the food must be given with scrupulous care and regularity." These are weighty words, and it will be instructive to look at some of the points in detail which make for successful calf-feeding.

The Calf Box.—The preparation of the calf box previous to the introduction of the calf is all-important, because, unless this point is attended to, there is great danger of white scour, or similar diseases, attacking the calves and spoiling the results. The box should therefore be cleaned out, the floor disinfected, and the walls lime-washed. The ventilation should be thorough, in order to secure a gentle current of fresh air through the box. Light in the boxes is also good, provided it is not too strong. With these conditions fulfilled—namely, light, fresh air, and cleanliness—the calf may be safely introduced on to a comfortable bed of clean straw. Quietness is essential for rapid fattening, and unless each calf has a separate box, they should be tied up by the neck sufficiently short to prevent them reaching their neighbours. In the north of England they are often fastened between two stakes, to prevent the calves licking their coats ; while in Holland they are kept in small, dark boxes, with a round hole cut in the door, and a cover over it. When this cover is removed, the calf makes for the light, and receives its ration of milk for the time being.

Food.—The food used in the production of veal should be capable of giving a nice, whitish coloured flesh; and no more suitable food has been found than milk, the only drawback being that it is an expensive food, especially where there is a demand for it for human consumption. When eggs are cheap, a raw egg is sometimes switched in the milk; these are also fairly expensive for this purpose. It is therefore quite natural from an economic point of view that milk or cream substitutes, such as linseed jelly, ground linseed cake made into a gruel, or cod-liver oil, should be used; but the difficulty is, that when used most of these are apt to darken the colour, or otherwise diminish the value of the veal. The old practice of frequently bleeding the calves to whiten the flesh is now discontinued, and most folks consider that the lump of chalk which is sometimes placed in the manger is more for the purpose of correcting acidity in the calf's stomach than for whitening the flesh. After the calf gets two or three months old, the flesh gradually loses in colour, and it is not advisable to keep calves longer than this for veal; in fact, seeing that the best veal is produced by milk, and that milk is an expensive food, it is imperative, from a business standpoint, to veal calves as rapidly as possible. A little buttermilk may be used to advantage, as will be pointed out later on.

The Art of Feeding.—Great care has to be exercised in the hand-feeding of calves during the first few days of their lives; the same thing also applies to calves which have been bought in. In the first place, the milk should always be given direct from the cow, as it contains the animal heat, and has not undergone any changes in composition. A calf often drinks more than is good for it during the first day or two, if given

as much as it will take; then about the third day it is apt to turn sickly, scour, and refuse to take satisfactorily for a time. This gorging of the calf's stomach with milk often brings on "scouring," which might have been avoided had the quantity been restricted. During the first day, a pint each time, three times a day, is quite sufficient; and with an average Shorthorn calf of about 88 lbs. live weight at birth,

1½ galls. of milk per day by the end of the first week,
2 galls. per day by end of the second,
2½ galls. per day by end of the third, and
3 galls. per day by end of the fourth,

is as much as the calf can economically use.

As newly drawn milk is slightly alkaline in reaction, it is not uncommon for the appetite of the calf to lose its sharpness towards the third or fourth weeks when receiving a liberal supply of milk. The writer found it a distinct advantage to add to the sweet milk a little buttermilk, a small quantity at first, increasing it to about 1 part of buttermilk to 10 parts of sweet milk. This was begun when the calves were a fortnight old, and had the effect of sharpening their appetites, with the result that the increases obtained during its use sometimes amounted to over 20 lbs. per week. The buttermilk has no injurious effect on the quality of the veal, and calves fed on milk with a little buttermilk added, often scale heavier weights than one would anticipate from their apparent size.

Another point to bear in mind is that frequent feeding at regular intervals is a decided advantage. Average Shorthorn calves, fed three times a day, may be made 150 to 160 lbs. (11 stones) live weight and ready for the butcher by the time they are a month old; while

PLATE XVIII.

[illegible] Author.

Pedigree [illegible] Mr. Percy P[illegible] Penrowl Court, Ross, Herefordshire.

[illegible] point of view

B. Group of well-bred Dairy Shorthorn Calves being hand-reared at Lord Lilford's Home Farm, Northants.

with calves fed twice a day, it will take an extra week, and even then they will scarcely be as heavy as those fed three times a day. To put it another way, by feeding three times a day, about 9½ lbs. milk give 1 lb. of increase, while with feeding twice a day, it will take 10½ to 11 lbs. of milk to give the same result. The extra week taken to fatten is also a consideration with veal in England, because as soon as Easter is past, one is generally faced with a falling market; and with two equally good calves, one sold at Easter, and the other a week after, the difference in price might possibly be 1d. less for each pound of veal, which means about 8s. less for a calf weighing 160 lbs. live weight.

It is important to know how much the milk used for vealing calves would bring in if made into cheese or butter. Taking 9½ lbs. milk as yielding 1 lb. increase in live weight, 1 gall. milk as yielding 1 lb. cheese, and 2½ galls. milk 1 lb. of butter, the following comparative values are arrived at: when veal is selling at 9d. per lb., cheese made from the same quantity of milk will need to sell at 5·82d. per lb., and butter at 14·56d. per lb. This takes no account of the extra labour involved in cheese and butter making, and it must not be forgotten that the colostrum could not be used for butter or cheese making, although very suitable for calf-feeding; both of these points make vealing calves compare more favourably than is at first apparent.

Conclusions.—It may be taken that 9d. per lb. for veal, 6d. per lb. for cheese, and 1s. 3d. per lb. for butter are very approximately equivalent quantities. These equivalents will only hold when the three processes are carried out equally well. Sixpence per pound is not

difficult to get for cheese, and 9d. per lb. is as much as can be expected for veal, so that when veal falls in value it will no longer compare favourably with cheese-making. Butter, on the other hand, often falls below 1s. 3d. per lb., and on this account veal production will often give as good, if not better, results than butter-making.

With careful feeding a gallon of milk, or even less, will easily yield 1 lb. of increase (equal to ·6 lb. veal), where the calves are fed three times a day. At this rate the return for milk consumed, including the colostrum, works out to be 5½d. to 6d. per gall.

Buttermilk, if available, should be included in the proportion of 1 part to 10 parts of milk, after the calves are a fortnight old.

Probably four to five weeks is as long as it is advisable to hand-feed calves intended for veal on a dairy farm, or until they have reached 160 lbs. live weight or 96 lbs. veal. An effort should also be made to have the calves fat at the time veal commands a high price, or the returns for vealing will not be great. It must usually be regarded as a convenient way of utilising surplus milk.

XXII. CALF-REARING.

The particular system one would adopt in the rearing of calves depends first of all on whether it is a dairy farm or an arable farm. In the former case the calves are generally reared by hand, while in the latter it is more usual to adopt the natural method by allowing the cows to suckle their calves. In the latter case the rent of the land would probably determine whether it is necessary for the cow to rear more than

one calf; *e.g.*, on £2 per acre land the cow would no doubt need to suckle two or three calves during the season, while on £3 per acre land she may suckle her own calf and another for say two months, then another pair for the next two months, and finally have a single calf up to the end of the period of lactation. As far as is practicable the calves should arrive not later than the end of March, because late calves do not make anything like the same progress as early ones.

With pedigree cattle, one does not see cows rearing two calves, as the fancy price obtainable for good pedigree stock will admit of more expensive feeding, and it is not unusual to find a calf taking all the milk that two cows will produce, especially with the beef breeds. Good breeding is, however, very important in commercial cattle for beef production, as they generally give a better return for the feeding in actual body increase than inferior bred ones. In like manner a milking pedigree is equally important for dairy cows.

Calves fed in the natural method need very little attention, as compared with the hand-reared ones, and the feeding of the cows is the same in both cases. When the calves are intended to mature early, they should be taught to eat linseed cake or bran and ground oats at one and a half to two months of age, and the quantity per day should be increased as the milk yield from the cow diminishes. The calves may be getting anything between 2 to 6 lbs. of concentrated food per head per day by the time they are twelve months old. Hay would at the same time be given when grass is not available.

Some persons appear to think that calves can be "roughed," *i.e.*, receive the roughest, mouldiest hay, and

inferior foods generally. This kind of treatment causes them to lose their "calf-flesh," with the result that they are longer in maturing, and never get the size and show the quality which they might have done had they been fed more liberally. Stock-owners are becoming more alive to the importance and profitableness of keeping calves intended for beef in good condition during the first twelve months. Early maturity or baby beef is the great aim of to-day, and it is wise economy to see that they do not lose their "calf-flesh."

Hand-Rearing.—This is practised on dairy farms where the milk is required for milk-selling, cheese-making, or butter-making. The calves are fed three times a day from two to four weeks on their mothers' milk, after which time the whole milk should be gradually substituted with separated milk and a fat substitute such as cod-liver oil, cotton-seed oil, or a suitable calf meal.

A word of caution is necessary at this point in feeding newly born calves which have been bought in the market or elsewhere. These calves are brought to their new home hungry and starved, and it is quite natural to give them on arrival a large feed of milk, to which the calf is not yet accustomed, consequently the calf scours, and in several cases is lost. A much better plan is to place it in a warm box, give it a dose of castor oil, and then feed it with about a quart of newly drawn milk three times a day for the first two or three days; after that gradually increase the quantity.

Where cod-liver oil is used as a fat substitute, one should commence when the calf is about two weeks old with a very small quantity at first, and gradually increase up to a maximum of 1 tablespoonful each meal by the end of the first month. It is best to pour

the oil into a pail first, and then after adding the milk, stir it well to mix the oil with it. The milk should then be fed immediately. As the calf grows bigger it requires more food, and this is best made up by feeding ½ lb. linseed cake per day in addition to the above-mentioned quantity of cod-liver oil. This method, although comparatively cheap, can only be adopted when pure oil, free from acidity, can be obtained.

Professor Hendrick (Aberdeen) demonstrated in 1908 that cotton-seed oil could also be used for this purpose.

Calf Meals.—The safest and best fat substitute, however, is a suitable made calf meal, provided it has been properly made.

The following are three very useful calf meals:—

1. Equal parts of ground linseed cake and fine middlings (seconds).
2. Ground linseed cake, 2 parts; oatmeal, 2 parts; and ground linseed meal, 1 part.
3. Oatmeal, 2 parts; maize meal, 2 parts; and ground linseed meal, 1 part.

The writer has found from experience that the first two of these give very good results. The third proved a very satisfactory mixture in the Irish Department of Agriculture's calf-rearing experiments. These calf meals are made into gruels by taking, say, for ten calves 2 lbs. of mixed meals in a pail, adding a little cold water, and stirring, so as to make the meal into a thick paste, then add 1 to 1½ galls. boiling water, and stir well to prevent any lumpiness in the gruel. Leave for about half an hour, then add milk, separated or skim milk, buttermilk, etc., as the case may be, until it is made sufficiently thin to drink; the temperature should not be above blood

heat when fed to the calf, otherwise the hair round its nose will come off. If boiling water is difficult to get, cold water may be used, as long as the gruel can be left for twelve hours. In this case it is necessary to warm the gruel before feeding.

The gradual substitution of whole milk by gruel may commence at the end of the second week; but if the whole milk is not urgently required, the calf will be all the better to get whole milk for the first four weeks. In about a fortnight's time the whole milk would be all substituted with separated milk and gruel.

Second month.—During the second month the calf meal gruel would be continued and gradually increased in quantity up to, say, $\frac{1}{4}$ or $\frac{1}{3}$ lb. per head per day along with $1\frac{1}{2}$ to 2 galls. separated milk. After a meal the calf may be tempted to suck at a little linseed cake or bran and oats until it will eat them out of a trough. In this way calves can be taken out of the sucking habit, and at the same time eat something which will do them good. It is wonderful how keen calves become after bran and oats.

It is important to know how to regulate the laxativity of a calf's diet. This is not difficult if one remembers that skim milk, separated milk, buttermilk, and fine middlings (seconds) have generally a binding tendency, while useful laxatives are linseed meal, ground linseed cake, whey, roots, and grass.

Third month.—The calf will no doubt have shown some inclination to eat a little nice, sweet hay, and it should now have the opportunity of eating some in order to develop its first stomach (paunch), which is as yet comparatively small. The gruel may now be withheld at mid-day, and replaced by a small feed of equal parts of "nutted" linseed cake, bran, and ground

oats. If available, a few pulped roots may be added to the cake, bran, and oats. The concentrated mixture works out at 19 per cent. albuminoids, 5 per cent. oil, and 9 per cent. fibre, which is a fairly satisfactory "standard" for calves.

Fourth month.—Gruel can now be gradually reduced in quantity, and the allowance of dry concentrated food increased to 1 lb. per head per day by the end of the month. The calf will require more hay or cut grass, unless it is out at grass. If no grass is available, continue with pulped, or better, fingered roots.

Fifth month.—Separated milk and gruel can now be discontinued. The cake and meal mixture would need to be gradually increased up to 2 lbs. per head per day by the end of the sixth month.

For the second six months the concentrated mixture may consist of 1 part linseed cake, 1 part bran, and 2 parts ground oats, giving a composition in the mixture of: albuminoids, 17 per cent.; oil, 6½ per cent.; and fibre, 9½ per cent.

Cotton cakes should not be given to cattle under twelve months old, as the undecorticated cakes are too high in fibre, and the decorticated cotton cake may also cause digestive troubles unless fed with caution. If fed at all, it should be in small quantities at a time, mixed with maize and ground oats.

In this way a lovely young animal may be made by the end of the first twelve months, and although it may not be quite so "bloomy" as one fed on whole milk, yet the difference will not be great, and it will have been produced much more economically (see p. 178). Mr Lindsay, in a paper before the Agricultural Discussion Society at Aberdeen University in 1905, said he preferred a pail-reared to a suckled calf for beef pro-

duction, because the latter did not weigh so heavy as it looked, on account of the carcass having too much calf-fat; while the pail-reared one gave a much better carcass of meat, and would give more satisfaction to the butcher and consumer.

Calf-Rearing Experiments.

Three common systems of rearing calves have been carefully tested in the exceedingly useful calf-rearing experiments carried out by the Department of Agriculture for Ireland in 1903-4. These results agree so closely with the writer's experience that the main points of these trials are given below.

The calves were all males of the Cross Shorthorn type, and were purchased locally (Collooney, Ireland) about the end of April, the average age being five weeks. After being divided up in four lots of ten calves each, they were fed for a few days to prepare them for the particular rations they were intended to receive.

First Summer.—During the first summer of twenty weeks, each lot was fed on a different rearing food, but after that, they all received exactly the same treatment, until the bullocks were seventy-three weeks old. The rations for the first twenty weeks per head were:—

Lot.

1. Whole milk, 6 quarts per day.
2. Skim milk, 6 quarts per day.
3. Separated milk and cod-liver oil (½ to 2 oz. per day).
4. Separated milk plus meal mixture of—2 parts oatmeal, 2 parts maize meal, and 1 part linseed meal.

Assuming the cost of whole milk to be 4¾d. per gall.; separated milk, 1d. per gall.; cod-liver oil, 5s. 6d. per gall.; linseed meal, 17s. per cwt.; maize meal, 6s. per cwt., the cost of food during the first twenty weeks (1904 prices) works out as follows:—

Lot.	Rearing Ration.	Total Cost per Head for 20 weeks.	Aver. Increase per Head in 20 weeks.	Cost per 100 lbs. of Live Weight Increase.
		£ s. d.	lbs.	£ s. d.
1.	Whole milk	4 1 2	288·3	1 8 1
2.	Skim milk	1 12 6	239·2	0 13 7
3.	Separated milk and cod-liver oil	1 10 5	241·0	0 12 7
4.	Separated milk and calf meal	1 7 8	265·2	0 10 5

During the last two weeks of the above period each calf received ¼ to ½ lb. maize meal while being weaned.

First Winter.—This period extended over twenty-four weeks, when each calf got an average daily ration of 1 lb. linseed cake and 1 lb. of crushed oats, in addition to rye grass and meadow hay *ad lib.*

Second Summer (twenty-nine weeks).—Linseed cake and crushed oats continued, but no hay was given after 26th April, the cattle being allowed to graze from 1st April 1904.

The following table gives the average increases per lot during the seventy-three weeks, in addition to the amount realised when the bullocks were sold at £1, 6s. 5½d. per cwt. (unfasted live weight), which is equal to £1, 8s. 4½d. per cwt. fasted live weight. The balances show what amount is left in each case to pay

for everything except the special feeding during the first summer (twenty weeks):—

Table giving Summary of Seventy-three Weeks' Feeding.

	Lot 1. Whole Milk.	Lot 2. Skim Milk.	Lot 3. Separated Milk and Cod-liver Oil.	Lot 4. Separated Milk and Calf Meal.
No. of Calves in lot	10	9	7	9
Aver. weight at commencement of experiment	133·6 lbs.	142·5 lbs.	145·8 lbs.	145·8 lbs.
Aver. weight at end of 73 weeks	893·9 ,,	786·8 ,,	830·2 ,,	847·7 ,,
TOTAL GAIN IN 73 WEEKS	760·3 lbs.	644·4 lbs.	684·4 lbs.	701·9 lbs.
Aver. value of Bullocks when sold	£10 11 0	£9 5 9	£9 15 11	£10 0 1
Cost of Rearing for first 20 weeks	4 1 2	1 12 6	1 10 5	1 7 8
BALANCES LEFT, to pay for all but cost of first 20 weeks' feeding	£6 9 10	£7 13 3	£8 5 6	£8 12 5
NET SAVING OVER WHOLE-MILK RATION	...	£1 3 5	£1 15 8	£2 2 7

It will be noticed that the average value of bullocks at end of experiment in Lot 4 was only 11s. behind that of Lot 1, while the cost of rearing during the first twenty weeks was £2, 13s. 6d. more for Lot 1 than for Lot 4, and this after taking the whole milk (Lot 1) at only 4¾d. per gall., while the calf meal and separated milk are fairly near their present value.

In the cod-liver oil lot the average results are very good, but three calves have fallen out of the

experiment, which is rather a significant point. It is not quite up to the calf meal lot either in live weight, increase, or economy

Cost[1] of Rearing a Calf for first Twelve Months.

If the calf is fed with calf meal and separated milk in addition to a fairly liberal supply of dry concentrated food, the cost of feeding for the first twelve months would be approximately as follows with an average Shorthorn calf:—

	£	s.	d.
First Week—			
Colostrum	£0	1	2
Second, Third, and Fourth Weeks—			
Mother's milk, varying from 1 to 2 galls. milk per day = 31½ galls., at 6d. per gall. . . .	0	15	9
Next Five Months—			
2 galls. of separated milk per day = 300 galls., at 1d. per gall.	1	5	0
Cakes and meals, varying from ½ to 2 lbs. per day = 157½ lbs., at ¾d. per lb. . . .	0	9	10
Summer Grazing—			
Twenty weeks, at 6d. per week . . .	0	10	0
Winter Months (seventh to end of twelfth month)—			
8 cwt. swedes, at 8d. per cwt. . . .	0	5	4
4 cwt. hay, at 3s. 6d. per cwt. . . .	0	14	0
5 cwt. cake, etc., at 7s. per cwt. . . .	1	15	0
COST OF FOOD FOR YEAR . . .	£5	16	1

If the calf had to be purchased, it would cost from £1 to £3. The cost of attendance and risk for the year may be put down at £2 to £3, hence the total cost of rearing the calf for the first year works out to approximately £8 or £10.

[1] As these are 1914 figures, the purchased feeding stuffs would need to be increased by 50 per cent. to bring them into line with 1924 cost.

In the Irish Department of Agriculture's winter and summer calf-rearing scheme it was shown that the autumn- and winter-born calves generally gave better results for the feeding than those born in spring. Take for example the following figures from vol. ix., No. 4, of the Department's Journal (1909), pp. 697-9, and reported on by Mr J. M. Adams, the Instructor in Agriculture:—

When Born.	Aver. Live Weight.			Aver. Number of Days Old.	Approx. Aver. Daily Increase in Live Weight.	Aver. Cost of Rearing per year.		
	cwts.	qr.	lbs.		lbs.	£	s.	d.
November .	5	1	27	378	1½	7	8	0
April . .	4	0	12	393	1	7	6	5

When the value of the calves was taken into account as well as cost of food, including grazing, attendance, insurance, and interest on capital, there was an average profit on the November calves of 9s. 1d. per head, while in the case of the April calves there was an average loss of 16s. 5d. In a similar trial carried out at Kinsale, and reported on by W. F. Prendergast, the County Instructor in Agriculture, very similar results were obtained; but the average loss on summer calves was reduced to 1s. 7½d. per head. There was also a bigger mortality in calves born in summer (9 per 100) when compared with those born in winter (0·5 per 100).

Turning out to Grass.

Calves which are born in the earlier months of the year should in most cases be turned out to grass in June. For the first day or two a couple of hours or

'LATE XX.

Photo by G. H. Parsons

Cox, "Prince

so would be long enough, so as to get them accustomed to the pasture grass and open-air life. After the first week they may be left out altogether. The gruel and cake mixture may be given in the same way as above, but the mid-day meal should be abandoned for two reasons :—

(*a*) They do not need it when they can eat grass.
(*b*) To encourage them to eat grass in the middle of the day only when the dew is off.

The effect of this interesting device is that the calves live on "dry" grass chiefly, and thus do not suffer from husk or hoose to the same extent. After the night feed of gruel, followed by concentrated dry food mixture, they lie down all night and hardly get up till called to the morning meal, after which they lie down again till 10 or 11 A.M. The middle part of the day is then spent in eating grass, and it is always advisable to keep them on a dry "short" pasture. It is generally advisable to keep them off young clover, or a mixture of rye grass and clover, in the autumn.

XXIII. DAIRY CATTLE.

Dairy cattle are kept mainly for the production of milk; but as milk is a perishable article of diet, it is necessary either

(*a*) To sell or use it immediately; or
(*b*) Make it into butter or cheese.

Butter should keep fresh and good for a week or a fortnight, while cheese would not be ripe and ready for eating until it is from a month to twelve months old. Dairy cows may, then, be required for milk, butter, or cheese production, and for each of

these branches of dairying a particular kind of milk is required.

Milk-selling.—In this case volume, or a large milk yield, is all important as long as it keeps up to the Government standard for butter-fat (3 per cent.), and solids other than fat (8½ per cent.). At the same time the milk should be free from taints, either from food or bad odours. The chief breeds of cows for this purpose are Shorthorns,[1] British Friesian, Ayrshire, South Devons, Welsh, Kerries, and Dexter Kerries. Shorthorns and British Friesians are suited to good land and heavy hand-feeding, while the other breeds will stand more exposure and thrive on scantier fare. First crosses often give excellent results, *e.g.* Shorthorn-Ayrshire.

Buttermaking.—Here volume of milk is not so important, but the amount of butter-fat which the cow yields during the year; *i.e.*, volume and richness in butter-fat must be considered together. It is also important that the fat-globules should be large, so that the cream, which consists largely of butter-fat, will separate all the more readily. Generally speaking, cream with large fat-globules gives the finest quality of butter. The most suitable breeds of cattle for this purpose are Jerseys, Guernseys, South Devons, and Shorthorns. Ayrshire milk has small fat-globules, and is consequently more difficult to churn.

Mr E. Mathews, in the 1909 Journal of the R.A.S.E., gives a tabular statement of the average amount of milk from different breeds which is required to yield

[1] In R.A.S.E. Milking Trials the average daily yields in 1924 were—Shorthorns, 55 lbs. 1 oz.; British Friesians, 61 lbs.; while in 1925 the average yields were 55 lbs. 10½ oz. and 67 lbs. 8 oz. respectively.

1 lb. butter. This figure is what is called the "butter ratio" of the milk.

Breed.	Ratio.	Gallons.
	lbs.	
Red Polls	30	3
Welsh	30	3
Shorthorn [1]	27½	2¾
Lincoln Red Shorthorn	27½	2¾
Ayrshire	27½	2¾
South Devon	26	2⅝
Kerry	26	2⅝
Dexter Kerry	26	2¾
Longhorn	22½	2¼
Guernsey	21	2 1/16
Jersey	19	1 13/16

Cheesemaking.—Milk for this purpose should have small fat-globules, and at the same time be fairly rich in butter-fat, so as to give a rich, mellow cheese. In this case the cream does not rise so quickly, with the result that the renneted milk coagulates or curdles before the cream has time to rise to the surface. The fat is then enclosed and carried down in the curd, giving a much richer cheese. Milk from the Ayrshire breed is specially suitable for cheesemaking on account of the fat-globules being small, but thousands of tons of cheese are made each year from Shorthorn milk, which if skilfully managed gives excellent results.

The importance of milk rich in butter-fat for cheesemaking has been demonstrated by Mr D. K. Robb, F.H.A.S., of the West of Scotland Agricultural College, in a most convincing manner. The following table shows the amount of cheese made from 10 gallons of

[1] At the R.A.S.E. Butter Trials in 1924, Shorthorns had a butter ratio of 32·41 lbs., and British Friesians 30·07 lbs.; while in 1925 the figures were 27·73 lbs. and 40·11 lbs. respectively.

different qualities of milk in each case, in addition to the return per gallon, assuming the cheese made from poor milk to be as valuable as that from richer milk, which is a big assumption :—

Quantity of Milk taken.	Percentage of Fat.	Yield of Green Cheese.	Value of Green Cheese, at 6d. per lb.	Return of Milk per Gallon based on yield of Cheese.
gallons.		lbs.	s. d.	d.
10	2	6·02	3 0	3½
10	2½	7·25	3 7½	4¼
10	3	8·45	4 2½	5
10	3½	9·63	4 9	5¾
10	4	10·45	5 2½	6¼
10	4½	11·32	5 8	6¾
10	5	12·39	6 2½	7½

These figures show that the value of milk for cheese production varies with its richness in butter-fat. Within the above limits (*i.e.*, 2 per cent. to 5 per cent. butter-fat), the value increases at the rate of 1½d. per gallon for 1 per cent. increase in butter-fat content.

Points of a Typical Dairy Cow.

Head.—The head should be neat and intelligent, fairly wide between the eyes, broad between the nostrils, fairly long from eyes to nose, and the eyes rather prominent.

General appearance.—A "wedge-shaped" body generally denotes milk; *i.e.*, the withers should be fine; ribs not too well arched, but long, giving great depth to the body. The loin and hind quarters should be as wide as possible, giving the wedge-shape from withers to hind quarters. Further, when the cow is viewed from the side, the fore quarters should be comparatively light consistent with a good constitution, and

PLATE XXI.

Typical British Friesian Cow, "Northl... Mercedes P.L." Female Champion, R.A.S.E. Show, 1924.
Bred by G. Holt Thomas, Esq., N...don, High Wycombe, Bucks.

[To face p. 184

the body increase in depth and massiveness from the fore to the hind quarters.

Leg bones should be rather fine, and the tail not too thick.

Skin.—This is a most important point, as good milkers generally have a rather thin, soft, flexible skin with an oily feel. The hair should be soft and velvety. Hidebound cows with coats of coarse hair are not generally good milkers.

Udder.—This varies with the different breeds in shape, but should in all cases be symmetrical, with teats of equal size, big enough to grasp with the hand, but not too large, and placed well apart. The udder should generally extend well forward and well backward, giving great capacity. The skin of the udder should be very elastic, and shrink considerably after milking each time.

General Indications regarding Quantity and Quality of Milk.—Cow wedge-shaped, fine along the shoulders and back, slender neck, thin tail; milk-veins large, prominent, branched, and big at the point where they turn into the body (milk-wells).[1] Udder capacious, soft and elastic. Escutcheon or milk mirror, which is formed by hairs on back of udder, pointing upwards instead of downwards, is regarded by some as a reliable guide. This peculiar marking often continues upward in a broad band. At the same time the back part of udder may have tufts of hairs or "ovals" on it, and these are considered a good sign, especially if the blood-vessels are prominent on back of udder and considerably branched.

Quality is indicated by a thin, flexible, mellow skin; soft velvety hair; skin inside ears yellowish; in fact

[1] The further the milk wells come forward, the more hopeful is the prospect of the cow being a good milker.

the skin generally should have an oily feel. Horns also slightly yellow at base.

Building up a Herd.

It is very useful to know the various points of a good dairy cow, but in breeding dairy cattle successfully one should know something of the milking pedigree or milk record which the respective parents have. The keeping of milk records has been one of the secrets of success in countries like Denmark, and during more recent years it has become fairly common in this country. This enables the breeder to select from his herd those cows which give a large quantity of milk each year, which is at the same time rich in butter-fat.

The bull used on a dairy farm should also be carefully selected, possess a strong masculine body, a good constitution, and in addition a good milking pedigree. The following example will show the care which has been taken at the Geneva Experimental Farm (New York State) with their Jersey stock bull (Blue Belle Prince). In addition to being entered in the herd book, he possessed the following qualifications :

BLUE BELLE PRINCE, No. 70,075. Born 6th October 1904.	*Sire*—OAKLANDS NORA 2ND LAD.
	Dam—BLUE BELLE PRINCESS, No. 157,364.
	Milk record . . 8121 lbs.
	Butter . . . 557 lbs.

The bull's dam had therefore a record of giving over 5 cwts. butter in a year. The advantages of keeping these records are that they tend to raise the milking capacity of dairy cows very considerably, inasmuch as individual records are kept which enable one to discover and discard poor and unprofitable milkers.

Typical Ayrshire Cow "[illegible] Mayflower." She scored 1st in Inspection, 1st in Milking Trials, won the Barham and Shirley Cups, together with the British Dairy Farmers' Association's Gold Medal at the London Dairy Show in 1925. Also 1st Prize at Royal and Highland Show in 1925.

[To face p. 186.

The quality of the milk is also ascertained, and in this way each animal has a "milking" pedigree which is a marketable commodity, seeing that it will either increase or mar the selling price of the animal.

When milk records are kept, cows can be fed according to their milk yield, which is the only logical way. These records give the owner important information with regard to the variation of composition due to period of lactation, season of the year, or other causes. Although a gallon of milk weighs from 10¼ to 10⅓ lbs., it is generally sufficiently near and much more convenient in these records to consider 10 lbs. milk as being equal to 1 gall., seeing that measuring the milk is rather unsatisfactory.

The Ministry of Agriculture issue an Annual Register of Dairy Cattle with authenticated Milk Records, with the object of: (1) encouraging the keeping of authenticated milk records, and the breeding of high-class dairy cattle; (2) encouraging dairy farmers to use pedigree bulls bred from a milking strain; (3) providing dairy farmers with a list of such bulls.

The register is divided into two sections: (1) dairy cows; (2) pedigree bulls for dairy herds.

In Section I. (*a*), cows are included which attain the following standard for the last milk-recording year:

Breed or Type.	Yield (in lbs.).
Friesian	10,000
Ayrshire, Blue Albion, Lincoln Red Shorthorn, Red Poll, Shorthorn, and Crossbreds . . .	9,000
All other breeds or types . .	8,000

In Section I. (*b*), the Ministry award Certificates of Merit in respect of cows which have calved not less than three times during a period of three consecutive

milk-recording years, and have attained the following standard of milk yield:—

Breed or Type.	Yield (in lbs.) for three years.
Friesian	26,000
Ayrshire, Blue Albion, Lincoln Red Shorthorn, Red Poll, Shorthorn, and Crossbreds . . .	25,000
All other breeds or types . .	24,000

In Section II. (*a*), a bull must be entered or accepted for entry in the herd book of its breed, and its dam and sire's dam must have given the above-mentioned standard yield prescribed for their breed or type in any particular year.

In Section II. (*b*), bulls accepted must have two or more daughters which have given the above-mentioned standard yield of milk prescribed for their breed or type in any particular year.

This annual register is the natural outcome of the Ministry's Milk Recording Scheme, which has done so much to raise the average milk yield of the dairy cows kept in this country.

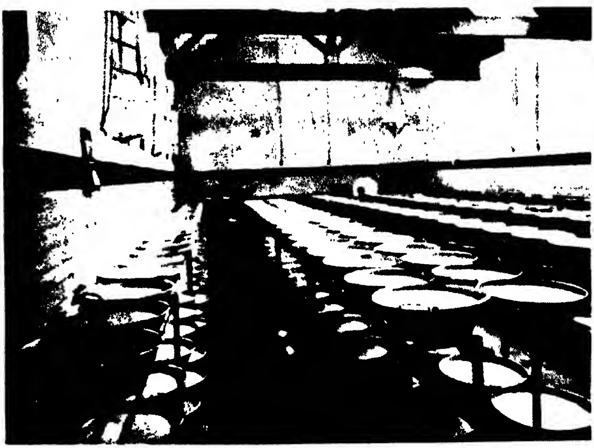
Butter Tests.

In order to encourage the breeding of dairy cows which yield a large quantity of good-quality milk, the British Dairy Farmers' Association give valuable prizes each year at the London Dairy Show on the following scale of points:—

The National Butter Challenge Cup, value 100 guineas, will be awarded to the owner of the cow or heifer of any breed, entered or eligible for the Herd Book of its breed, gaining the greatest number of points per 1000 lbs. live weight in the butter test. The Cup to be won three times in succession or four times at

PLATE XXIII.

A. Typical Jersey Cow in the Cathedral Dairy Company's herd, at Messrs. Loram Bros., Rosamondford, near Exeter.



[Photos by Messrs Loram Bros.

B. Devonshire Clotted Cream.—The Cathedral Dairy Company's Model Creamery at Rosamondford.

[To face p. 188.

intervals before becoming the absolute property of the winner.

A Silver Medal of the Association will be presented to each year's winner of the Cup.

The prizes will be awarded according to the following scale of points :—

One point for every ounce of butter; one point for every completed ten days since calving (calculated to the first day of the Show), deducting the first forty days. Maximum allowance for period of lactation, 12 points.

Fractions of ounces of butter, and incomplete periods of less than ten days, to be worked out in decimals, and added to the total points.

In the case of cows obtaining the same number of points, the prize to be awarded to the cow that has been the longest time in milk.

No prize will be given to animals in the butter tests which do not come up to the following standard :—

Breed.	Cows under 5 years. Points.	Cows 5 years and over. Points.
Pedigree Shorthorns	30	34
Non-pedigree Shorthorns	30	34
British Friesians	30	34
Lincoln Red Shorthorns	30	34
Jerseys	30	35
Guernseys	27	30
Ayrshires	27	30
Red Polls	30	34
South Devons	30	34
Kerries	26	29
Dexters	26	29
Devons	27	30
Welsh	27	30
Blue Albions	30	34

Certificates of Merit and Highly Commended Cards will be given to animals, other than prize winners, that reach the above standard.

Feeding the In-Calf Cow.—It is usual for cows to have their first calf when they are from two to three years of age. During the pregnant period they should get plenty of fresh air and exercise in addition to a fairly liberal supply of nourishing food, which will enable the development of the fœtus.

Generally speaking, cotton cakes, brewers' grains, frozen turnips, and potatoes should be avoided. Heavy feeding of concentrated foods, and especially cotton cakes, appear to make the cow subject to milk fever. As the time of calving approaches, the ration should be of a more laxative nature. Bran mashes are especially useful, and if these are not sufficient, the cow may be given a dose ($\frac{1}{2}$ to 1 lb.) of Epsom salts.

XXIV. MILK SECRETION.

Milk, like other secretions in the body, is produced from the blood, the nutrients in which have been supplied by the consumption of food (see pp. 24 to 31). The particular organ concerned in giving milk its characteristic properties is called the udder (mammary gland).

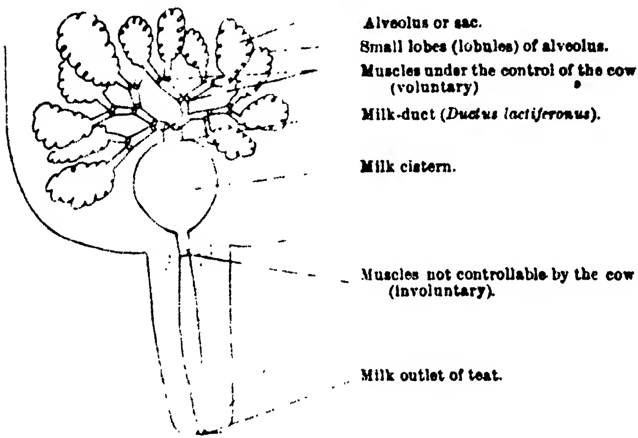
The udder consists of two halves, right and left. Each half is again divided into two more or less independent "quarters," with separate outlets called "teats."

The interior of each quarter is made up of yellow glandular tissue, which is very diagrammatically represented in the figure on p. 191.

The udder is well supplied with blood, which is forced round the circulatory or vascular system by the heart, and it is reasonable to assume that the quantity and quality of milk yielded should bear some relation

to the amount and quality of the blood circulating through the udder each day.

The course taken by the blood is along the principal artery (aorta) leading the blood away from the heart. This main artery branches periodically in order to supply the various organs with blood, but the branch leading the blood to the udder passes along backwards to the hind quarters, then in a downward direction



Structure of a Quarter.

along the thigh until it enters the mammary gland, inside which it divides in the usual way into a large number of very fine blood-vessels (capillaries) with very thin walls. The capillaries practically mat themselves round the alveoli, and in this way the alveoli are able to absorb from the blood any nutrient material which they require for the manufacture of milk. These capillaries gradually join up again as they leave the front part of the udder, into a large blood-vessel called the "milk vein," which follows the lower part of the

abdomen forwards till it almost reaches the posterior part of the breast bone where the veins turn inwards, thus leading the blood back to the heart. These points of turning are called the "milk-wells."

Theories of Milk Secretion.—(*a*) Up to 1840, milk was considered to be merely filtered blood, the milk glands acting simply as a filter. Blood certainly resembles milk in several respects, but there are important chemical differences at least, which make this theory untenable. The resemblances and differences are placed in apposition.

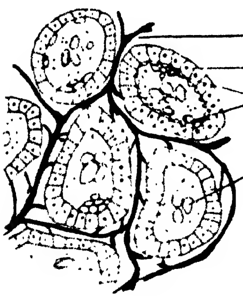
Milk	*Blood*
Consists of fat-globules floating in a serum (separated milk).	Consists of blood corpuscles floating in "blood" serum.
Fat globules give characteristic yellow colour to milk.	Blood corpuscles give characteristic red colour to blood.
Milk is 1·032 times as heavy as water.	Blood is 1·055 times as heavy as water.
Milk left exposed to air generally curdles or sours.	Blood left exposed to air clots through formation of fibrin.
Soda salts predominate in ash of milk.	Potash salts predominate in ash of blood.
Fat in milk is comparatively rich in volatile fatty acids.	Fat in blood consists largely of non-volatile fatty acids.

The quantity and quality of milk has not been affected very greatly when different foods have been experimentally fed, so long as the ration used was sufficiently rich in nutrients. This result should naturally have been brought about if milk were only filtered blood, but as milk constantly exhibited the last two chemical differences given above, another theory had to be formulated.

(*b*) The modern theory is that milk is manufactured by the mammary glands from the blood. The way in

which it is manufactured will now be discussed. One fact which accelerated this idea was that colostrum was found to contain certain minute bodies called "colostrum corpuscles." Under the microscope, these exhibited traces of cell structure apparently like shed (epithelial) cells from the alveoli. This suggested that milk may be a product formed by the decomposition of the cell walls of the alveoli.

These alveoli have very thin walls, consisting of a single layer of minute living cells, which are in fact the secreting cells of the mammary gland. If a section were cut so as to remove the tops of the lobules of an alveolus, it would have approximately the following appearance under the microscope:—



Capillary blood-vessels.

Epithelial cells of alveolus.

Epithelial cells breaking up; the cell itself apparently disappears in normal milk.

Fat-globules among the other secretions which constitute milk.

The method of secretion can now be fairly easily followed. The capillary blood-vessels which form a network round these alveoli supply the glands of the udder (mammary glands) with blood which is constantly circulating through the udder. Part of this is absorbed by the thin walls (epithelial cells) of the alveoli, and these epithelial cells commence to grow towards the inside of the alveolus, but as fast as they grow inwards the contents of these cells are

apparently deposited inside the sac or alveolus. It is, however, somewhat difficult to trace the walls of these "shed" cells after, say, the second week of the lactation period, and it is possible that they are dissolved in some way or other, seeing the cell walls are so very thin.

Professor Cave[1] holds the view that the greater part (say two-thirds) of the milk-flow is actually manufactured during the process of milking, by what is called "reflex action," and anything which can disturb this function will cause a difficulty in milking, and also a less amount of milk will be obtained.

It is probable that the various constituents of blood and lymph, as well as the substance of cell glands, are all utilised in the formation of milk constituents. The difference in composition of the fat of milk as compared with that of blood may be accounted for by the mammary glands first of all splitting up the fat in the blood and then rebuilding or reconstructing it in such a way as to give it the peculiar character of butter-fat (cp. p. 35).

Colostrum:—The milk given during the first few days after calving is of a rich yellow colour, glutinous, and possesses laxative properties which nature considers necessary for newly born animals. Chemically it is very rich in albuminoids (16 to 18 per cent.), the greater part of which is present in the form of albumen and not casein, as is the case in normal milk; hence a skin rapidly forms on the surface of colostrum when it is heated. At the same time it is poor in sugar (2½ per cent.). It gives a rich yellow colour to dairy produce, but should not be used for butter till the end of the first week; and at least another week should transpire before it is used for cheesemaking.

[1] Special article *Agricultural Gazette*, 4th April 1924.

It is not a good practice to remove the whole of the milk from the udder during the first day after calving, as there would be danger of the udder being chilled by this sudden removal of milk which has been accumulating for some days. The best plan is to milk the cow three or four times during the first day, and only take about half of the milk away at each time. After this, the whole of the milk may be removed at each time of milking.

Normal milk from Shorthorn cows contains about 3½ per cent. albuminoids, consisting chiefly of casein (curd), the albumen present only amounting to something like ½ per cent. Fat varies from 3 to 4½ per cent., as in Shorthorns, Ayrshires, etc.; and 4 to 6 per cent. in the case of Jerseys, Guernseys, and South Devons.

Kind of Animal, etc.	Water.	Fat.	Albuminoids.	Sugar (Lactose).	Ash.
	per cent.	per cent.	per cent.	per cent	per cent.
Cow (colostrum) . .	75½	3½	17	2½	1½
" (normal) . .	87¼	3¾	3½	4¾	¾
Mare (") . .	90½	1¼	2	5¾	½
Ewe (") . .	80½	7	6½	5	1
Goat (") . .	86	4¾	4	4½	¾
Sow (") . .	84	4¾	7	3¼	1
Ass (") . .	89½	1¾	2¼	6	½
Bitch (") . .	75¾	9½	11	3	¾
Cat (") . .	82	3½	9	5	½
Skim milk . . .	90	¾	4	4¾	½
Separated milk . .	90½	¼	4	4¾	½
Cream (thin) . .	67¼	26	2½	3¾	½
" (thick) . .	41	55	1½	2¼	¼
Butter	10	88	1	1	
Cheese . . .	40	30	25	5	

The above table gives the average composition of colostrum (biestings, etc.) and normal cow's milk of

medium quality, *e.g.* Shorthorn. At the same time the average composition of the milk of other farm animals is given for comparative purposes; and for convenience, that of dairy produce as well.

Butter-fat.—A knowledge of the chemical composition of butter-fat is of some importance, if the feeding of dairy cows is to be properly understood. It consists of glycerine combined with various fatty acids, which may be—

(a) *Non-volatile* and insoluble in water (palmitic, stearic, myristic, and oleic acids). Palmitic acid combined with glycerine gives a fat called palmitin; stearic acid and glycerine, stearin; etc.
(b) *Volatile* and soluble in water (butyric, capric, caproic, and caprylic acids).

Volatile means that the acids are capable of being distilled off.

The chief point to bear in mind here is that the characteristic feature of butter, as compared with margarine, etc., is that the former is comparatively rich in *volatile* fatty acids, while the latter is very poor. These volatile acids are also responsible for the fine full flavour one gets in good samples of butter, whereas ordinary margarine possesses a tallowy, insipid flavour.

Margarine consists chiefly of non-volatile fatty acids which are insoluble in water. These are also common to butter, but not to the same extent. Generally speaking, the firmer and more solid the fat is at ordinary temperature, the larger is the proportion of palmitin and stearin in it; while the softer and more liquid it is, the larger is the proportion of olein.

The following very simple, household method of distinguishing butter from oleo-margarine has been

taken from Farmers' Bulletin, No. 131, of the U.S. Department of Agriculture, Washington, D.C. To make this test, a small amount of butter or oleo-margarine, as the case may be, approximately the same size as a good big cherry, is taken and heated, gently at first, in a tablespoon held over a spirit lamp or gas stove, stirring the fat about at the same time with a match stalk. As soon as the fat becomes melted, bring the spoon nearer the flame so as to boil the oily substance as briskly as possible. Stir the contents thoroughly during boiling two or three times, and always shortly before boiling ceases.

Oleo-margarine boils noisily, sputtering more or less, and produces little if any foam, while genuine butter boils usually with less noise and produces "abundance of foam."

Circumstances affecting the Quantity and Quality of Milk.

The following are some of the chief circumstances affecting the quantity and quality of milk :—

1. **Soils and Manures.**—Limestone soils give a better quality of milk. It is sweeter, keeps better, requires less rennet to curdle the milk, and the curd does not need so much scalding when used for cheese-making.

Milk from low-lying marshy pastures is apt to deteriorate quickly. The butter and cheese made from the milk of cows grazing on such pastures have not the desired flavour and aroma. Draining should generally precede any manurial treatment in improving such pastures.

Fairly heavy dressings of nitrate of soda applied in spring, force the grass considerably, and are not

desirable, seeing they are likely to result in the cows scouring and, in some cases, going "off their milk."

Bone meal is undoubtedly an excellent manure for pastures, but if applied in spring, on cheesemaking farms, it taints the milk so much that the cheeses will taste of it for several weeks or even months. At the same time the cheeses will "heave" a good deal during ripening. Bone meal should therefore be applied in the winter time, in order to give time for the rain to wash it into the surface soil before the grass begins to spring.

Many pasture soils grow grass of inferior quality, and all kinds of objectionable weeds, simply because the land is too poor to grow good pasture plants. The effect of a dressing of slag (6 cwts.) and kainit (2 to 3 cwts. per acre) has generally a marked effect on the quality of the herbage. The grass becomes sweeter, white clover grows in abundance, stock cling tenaciously to it, and the land carries a larger number of stock per acre.

This point was demonstrated at the Midland Agricultural College, in their "manuring for milk" experiment, where 8 acres of pasture-land received a dressing of 10 cwts. ground lime; half of this area received in addition 4 cwts. of super (35 per cent.) and 1½ cwts. sulphate of potash. During the first summer the 4-acre plot, which received the phosphates and potash, carried at first two, but later three cows, while the remaining 4 acres only carried two. At the end of the first season (1909), the cows feeding on the manured plot produced very nearly 3489 lbs. more milk than those fed on the unmanured plot. This amounts to an increased milk yield, in favour of the manure, of 84 galls. per acre. The increased yield

PLATE XXIV.

Photos by Author

B. Pedigree Dairy Shorthorn Cow, "Baroness Stately," owned by Lord Lilford, Lilford Hall, Oundle, Northants.

This cow yielded over 800 galls. last year

[*To face* p. 198

of the cows fed on the manured plot has been more than maintained during the seasons 1910, 1911, and 1912, the average increase in milk yield per acre, due to this manuring, now standing at an average of 93 galls. per acre.

2. Breed.—Milk from Jersey cows contains a much higher percentage of butter-fat than is the case with that from Shorthorns or Ayrshires, and the butter made from it is both firmer and of a richer yellow colour. The richer colour in butter from Jersey cows is largely due to its containing a comparatively large proportion of "volatile" fatty acids, which can very probably be accounted for in two ways:—

(*a*) Careful selection through successive generations.
(*b*) The tethering system.

In the latter case, the cows have been accustomed to handling from their youth up, and through constantly being tethered, have not developed such a wild disposition as, say, an Ayrshire. Excitability, or wildness of any kind, on the part of the cow producing the milk appears to affect the colour of butter-fat adversely.

This is also an argument against using the dog too freely when driving milking cows, as well as against any rough treatment in the cowhouse.

3. Individual Character of cows of the same breed.—This is sometimes called "individuality," and refers to the fact that both the quantity and quality of the milk yielded by any particular breed of cows varies very considerably with individual animals of that breed. *E.g.*, in the milk record tests carried out by the Lancashire County Council with Dairy Shorthorn cows during the lactation period of 1906, one notices that one of the worst milkers gave 404

galls. of 4·1 per cent. milk, while the best yielded as much as 928 galls. of 3·4 per cent. milk for the year. In the former case, the cow produced about 162 lbs. pure butter-fat, while the latter gave fully 315 lbs. Wide differences are to be found, of a similar nature, in all breeds, due to their individual characteristics.

4. Period of Lactation. — This point may be illustrated from the Ayrshire milk records, the keeping of which were supported by a grant from the Highland and Agricultural Society of Scotland. Mr John Spier included the record of every available cow at the time, and obtained the following interesting figures:—

Weeks since Calving.	Average Milk Yield.	Average per cent. Fat in Milk.
Under 1 week	26·3 lbs. per day	3·75
" 2 weeks	28·9 "	3·56
" 4 "	31·9 "	3·23
" 6 "	32·1 "	3·31
" 8 "	32·0 "	3·32
" 10 "	32·7 "	3·34
" 12 "	34·2 "	3·42
" 14 "	34·1 "	3·42

It will be noticed that the yield of milk gradually increased up to the twelfth week. After that, it began to fall off. With regard to the quality, the percentage of fat decreased till the end of the fourth week; after that the fat gradually increased in proportion.

5. Age of Cow.—In the Highland and Agricultural Society's Journal for 1909, Mr Spier, in his report of the Wigtonshire Milk Record Society, makes a tabular statement of the average quantity and quality of milk yielded by all (available) cows, according to their age,

which had completed their lactation periods. The following will be sufficient to demonstrate the point:—

Age of Cows in years.	Number of Cows on which figures based.	Average Milk Yield in gallons.	Average per cent. of Fat in Milk.
2	22	450·6	3·88
2½	38	495·5	3·89
3	320	565·8	3·87
4	189	656·4	3·74
6	159	734·7	3·67
8	87	774·5	3·64
10	46	804·8	3·56

The chief points to notice are that the yield gradually increases with the age of the cow, and the percentage of fat was highest in the milk of young cows or heifers, but after the third year the quality gradually declined.

6. First and Last drawn Milk.—The first quart of Shorthorn milk may not contain more than 2 per cent. of fat, and sometimes less, while the last quart drawn at the same milking may run up to 6, 7, or 8 per cent. fat.

Difference in Composition between First and Last drawn Milk.

	Water.	Albuminoids.	Fat.	Total Solids.
	per cent.	per cent.		per cent.
First drawn milk	89·42	3·70	1·20	10·58
Last drawn milk	83·37	3·48	7·88	16·63
Stripping . .	80·60	3·37	10·80	19·40

The strippings may quite easily contain 10 per cent. fat. These results are not altogether explained by the cream being lighter and partially separating in the udder, but partly by the greater resistance or friction

the fat-globules have to overcome in passing down the milk-ducts into the milk-cistern in the udder. The thinner part (serum) therefore finds its way into the milk-cistern with less difficulty.

Dr Babcock (Wisconsin) found, from several trials, that quick milking produced 2 to 13 per cent. more milk which was a tenth richer in butter-fat than that produced by slow milking. This superiority was continued for several months, until the milk-yield of the cow naturally began to decline.

7. Morning and Evening Milk.—Generally speaking, the morning milk is larger in quantity and poorer in fat than evening milk. This may be partly due to the vitality of the cow's system being lower during the night than day time, more especially when the days are short, but the chief cause is undoubtedly the unequal periods between the times of milking. This point is dealt with in Dr Lauder's report (Edinburgh and East of Scotland College of Agriculture), Bulletin XI., from which the following table is taken :—

Effect of Milking at Equal and Unequal Intervals on Composition of Milk.

Morning (6.30 A.M.).		Evening (4 P.M.).	
Fat in Milk.	Total Solids.	Fat in Milk.	Total Solids.
3·14 per cent.	12·01 per cent.	4·07 per cent.	12·89 per cent.
Morning (5.30 A.M.).		Evening (5.30 P.M.).	
Fat in Milk.	Total Solids.	Fat in Milk.	Total Solids.
3·67 per cent.	12·62 per cent.	3·70 per cent.	12·42 per cent.

Milking the cows at equal intervals has reduced the difference in fat content of milk from ·93 per cent. to ·03 per cent.

8. Time of Calving.—Trials carried out by the Department of Agriculture for Ireland (1907-8) indicate that the November calvers gave, on an average, 160 to 180 galls. more milk in a year than the April calvers (see p. 225).

Effect of Food.

Pasture is the natural food of the dairy cow during the summer months, and if a sufficient supply is available of "good quality," the milk-yield will most likely be kept up to the maximum. It is very doubtful, in this case, whether the feeding of concentrated foods in addition to pasture would have any permanent effect in improving the yield of milk, or the percentage of fat in it.

If, however, the pasture is only poor in quality, and the cow is not receiving an adequate amount of nutrient material in the form of forage crops, etc., the most notable effect of the addition of suitable concentrated food to the ration would be to increase the milk-yield; but there may be, at the same time, an increase in the proportion of fat in the milk, *i.e.*, the milk may also be, and possibly would be of better quality. Liberal feeding of concentrates would therefore push the yield of milk to the maximum; above this point fattening would most likely take place. The cost of producing this increased flow of milk has also to be kept in mind.

During the winter months, however, the pasture grass, if available, has not the same feeding value, and it is necessary on dairy farms generally, to lay up a store of hay, straw, roots, and either home-grown or

purchased concentrates; consequently, in order to produce milk one has to try and compound a ration which will approximate to pasture grass in its efficiency as a milk producer. Before one can do this it is necessary to know something of the various effects of concentrates, fodder crops, and roots on the quantity and quality of milk produced when fed to dairy cows.

The outstanding features of milk produced by cows feeding on good pasture, as well as the butter, etc., made from it, are:—

(*a*) The milk is, comparatively speaking, abundant in quantity, and of good quality.
(*b*) The butter made from it has a rich yellow colour.
(*c*) The butter-fat is generally firm at normal temperatures, but not hard and tallowy like margarine. If well made, it possesses a sweet, full, nutty flavour, and a pleasant aroma.

These are standards which we shall need to keep in mind, and as fodder crops and roots form the basal part of the ration, we will consider the effect of these crops on dairy produce first.

Fodder Crops.—Green forage crops have a similar effect to that of pasture grass, but green clover, if fed in considerable quantity, is apt to give a tallowy butter.

Straw (usually oat straw) gives a very pale and rather hard butter; while meadow hay butter is not so pale, but resembles it largely in the latter characteristic.

Root Crops have similar laxative properties to grass, but the butter produced from such milk varies in colour according to the kind of root crop fed; *e.g.*, mangels and sugar beet give a pale-coloured butter, while carrots give a nice yellow colour to it. At Wye College, cows which were giving a pale-coloured butter

from mangels had 28 lbs. carrots per day substituted, and it was found that the improved colour of the butter was evident in two to three weeks.

Cabbage and swedes both yield a fairly good coloured butter.

The feeding of an excessive quantity of turnips per day (112 lbs.) does not appear from Dr Lauder's report to have either increased the proportion of water in milk, or decreased the percentage of fat.

Dr Crowther states in a report on the variation of chemical composition of butter (1907), that "easily fermentable foods like grass, forage crops, and roots, appear to increase the proportion of volatile (fatty) acids, which give butter its peculiar flavour."

Certain root crops, viz., turnips, swedes, and cabbages, when fed in fairly large quantities, impart what is called a "turnipy flavour" to the milk, butter, etc., which is certainly not desirable. In order to avoid this defect, it is usually sufficient if the following precautions are observed :—

(*a*) Feed all such foods in moderate quantity only.
(*b*) They should be fed immediately after, and not before the cows have been milked.
(*c*) Decaying cabbage or turnip leaves, etc., should be removed from the cowhouse each day.

Concentrates.—The general effect is to push the milk yield to the maximum. Dry concentrates tend to improve the quality, and concentrates fed in the sloppy condition (sometimes called crowdy) tend to improve the quantity; but these results appear to be of a more or less temporary character, and are much more marked in the early than in the later part of the lactation periods.

Concentrated Foods conveniently arranged for Compounding Rations.

	Albuminoids.	Oil.	Fibre.
I. CONCENTRATES RICH IN ALBUMINOIDS (OVER 20 PER CENT.) AND LOW IN FIBRE.			
(a) *Rich in Oil—*	%	%	%
Fish meal	55	4·0	...
Dried yeast	48	0·5	0·5
Earth-nut cake	46	10	5
Decorticated cotton-seed cake	41	9	8
Soya-bean cake (L)	43	7	5
Linseed cake (L)	30	10	9
(b) *Poor in Oil, but fairly rich in Carbohydrates—*			
Gluten meal	38	4	2
Gluten feed	26	3	6
Peas	23	1½	6
Beans (B)	25	1½	7
II. CONCENTRATES FAIRLY RICH IN ALBUMINOIDS (ABOUT 20 PER CENT.) AND HIGH IN FIBRE (OVER 10 PER CENT.).			
(a) *Rich in Oil—*			
Cocoa-nut cake	22	10	15
Palm-nut cake	17	10	22
Dried grains	20	7	16
(b) *Poor in Oil—*			
Egyptian cotton-seed cake (B)	22	5½	20
Malt coombs or cummins (L)	23½	2	12½
Bombay cotton-seed cake (B)	18	4½	22
III. CONCENTRATES VERY RICH IN CARBOHYDRATES (50 TO 70 PER CENT.) AND LOW IN FIBRE (MAXIMUM 10 PER CENT.).			
(a) *Fairly rich in Oil—*			
Oatmeal	15	8	3
Maize	10½	5	2
Rice meal	12	12	8
Oats	12	6	10
(b) *Low in Oil—*			
Coarse wheat middlings (thirds or sharps)	15	4½	8
Bran (wheat)	14	4	9
Fine wheat middlings (seconds) (B)	15	3½	5
Barley	10	2	5
Wheat	12	2	2
Rye	11½	2	2
Malt	10	2½	8
Locust beans	6	1½	6
Treacle (L)	10	...	...

* "B" = Binding in effect; "L" = Laxative in effect.

When the amount of concentrated food has reached a certain point, any increase in this amount does not give a corresponding increase in the yield of milk. In fact, in the Offerton Hall (Durham) experiments it appears that when the concentrated food was increased from 8 to 12 lbs. per 1000 lbs. live weight per day, the milk-yield was only increased by 2 pints per day, which must be considered a very small increased yield for an increase of 4 lbs. of concentrated food per head per day.

The relative proportion of the nutrients in the concentrated mixture appears to have some effect on the composition and quality of milk and butter. *E.g.*, in experiments carried out by the Midland Dairy Institute in 1896, with a basal ration of 50 lbs. roots, 10 lbs. chaff, and 6 lbs. hay per day, when the ratio of digestible fat (from linseed cake) to albuminoids in the ration was as 1 : 3, it appeared to increase the proportion of fat in milk, but the butter made from it was soft and inferior compared with that obtained when the proportion of fat to albuminoids in ration was as 1 : 6.

Dr Crowther states in his 1906 report that "heavy feeding of cakes rich in oil[1]—say upwards of 4 lbs. per day—tends to lower the proportion of volatile (fatty) acids, or in other words to increase the amount of margarine-like ingredients of the butter-fat." This supports the results obtained at the Midland Dairy Institute.

When "decorticated cotton cake or meal" is included to a greater extent than, say, one-third of the

[1] Recent experiments appear to show that, when large proportions of rice meal, etc., are used as a source of oil in the ration, the percentage of fat in the milk may be actually reduced.

concentrated food given, it tends to give a hard, pale-coloured butter with a tallowy sort of flavour. "Linseed cake," on the other hand, if rich in oil, gives a softer butter of fairly good colour, but it does not keep at all well.

"Brewers' grains," according to the Offerton Hall experiments (1907), when fed as part of the concentrated food in the ration (*i.e.* 20 lbs. per day) in summer, have the effect of increasing the daily milk-yield, more especially in the later period of lactation. There were, however, slight indications that they affected the percentage of fat in the milk adversely in the early lactation period, but this was not so appreciable towards the end of the lactation period. The effect in winter is similar, but the fat content of milk on the average is not appreciably affected.

Bean meal, pea meal, soya cake, fresh cocoa-nut cake, palm-nut cake, gluten meal, gluten feed, maize, ground oats, bran, etc., give a fairly good coloured and good flavoured butter.

The feeding stuffs which make butter a little harder than normal, or a little softer than normal, if they are fed in considerable quantity, are as follows:—

(a) *Harder than normal.*—Cotton cakes, palm-nut cake, pea meal, bean meal, green clover, vetches, and dry fodder crops, *e.g.* oat straw.

(b) *Softer than normal.*—Linseed cake, maize meal, rice meal, bran, and oatmeal.

Bitter Milk may be caused in the following ways:—

(*a*) Feeding inferior cotton cakes.

(*b*) Feeding brewers' grains in too large quantity: the bitter taste is more evident in the cream.

(*c*) The cow's udder being out of order. Bitter tastes caused by foods do not increase on standing, while those from udder complaints do.

(*d*) Cows eating orchard tree leaves carrying on their surface bacteria and yeasts which bring about this taint.

(*e*) Lack of cleanliness with dairy utensils: but this is produced after the milk leaves the cow, and has nothing to do with feeding.

"Ropy milk" may be produced when cows eat certain plants, such as butterwort (*Pinguicula*) and dog's mercury.

Strong objectionable flavours may be due to cows eating garlic, meadow saffron, sun spurge, buttercups, pine leaves, and shoots of trees, etc. Garlic is said to colour the milk yellow, while fenugreek and madder give it a red colour. Salt may become tainted by exposure to insanitary conditions, and impart a bad flavour to butter.

XXV. RATIONS FOR DAIRY COWS.[1]

In compounding rations for dairy cows it is necessary to keep in mind that fodder crops (hay, straw, etc.) and root crops will generally form the basal part of ration. These are bulky and poor in albuminoids. The fodder crops are very high in fibre, hence the concentrated mixture used should be:—

1. Rich in albuminoids;
2. Fairly rich in oil;
3. Low in fibre;
4. Attractive in flavour, and of a fairly laxative character.

[1] For brief outline of "Boutflour" method, see Appendix I.

The foods selected should have no injurious effect either on the quantity or quality of milk yielded, or the butter, etc., made therefrom. Another practical point is, when very rich concentrated foods are used, they should generally be "opened up" by adding a "bulky concentrate" such as bran or brewers' grains, so as to enable the digestive juices to act more effectively on the nutrients in the ration.

The following "standard" should be adhered to in making up the concentrated part of ration, although one would come fairly near by taking one-quarter from Section I. (p. 206), one quarter from II. (a), and one-half by weight from III.; or one-third from I. and two-thirds from III.

Feeding Standard for Dairy Cows.—The following standard for the *concentrated part of ration* will be found very suitable for cows receiving hay or straw along with roots:—

Albuminoids, 15 to 20 per cent.; oil, 4 to 6 per cent.; fibre, not exceeding 10 per cent.

When cows are receiving straw or inferior hay for the bulky fodder, up to, say, 21 lbs. per day, the composition of the concentrated food should approximate to the maximum: *i.e.*, albuminoids, 20 per cent.; and oil, 6 per cent. (see rations 4, 6, 7, and 8). Locust-bean meal may be used to sweeten a ration, and thus make it more attractive.

With regard to roots, cabbages, etc., these may be given up to 40 lbs. per head per day, or possibly more. If these are not available, their place may be taken with 20 to 35 lbs. wet brewers' grains, or in some cases treacle. In fact, the latter is very useful as a combined sweetener of foods and a laxative when the ration requires it.

The amount of concentrated food may be calculated for each cow by allowing

(*a*) ¼ lb. for every 100 lbs. live weight of cow;
(*b*) 2½ to 3½ lbs. for every gallon of milk produced per day.

With a cow of 800 lbs. live weight, and yielding 3 galls. milk per day, the amount required would be (*a*) $8 \times \frac{1}{4} = 2$, (*b*) $3 \times 3 = 9$, *i.e.* 11 lbs. in all per day.

The following mixtures of concentrates[1] for winter milk production are arranged for a cow of 800 lbs. which is giving 3 galls. milk per day. $A_{15\frac{1}{2}}O_4F_7$ means that its composition works out to be: albuminoids, 15½ per cent.; oil, 4 per cent.; and fibre, 7 per cent.

1. 3 lbs. bean or pea meal.
   3 lbs. bran (wheat).
   3 lbs. crushed oats.
   2 lbs. maize meal.
   $A_{15 \cdot 5}O_{4 \cdot 3}F_{7 \cdot 5}$.
2. 4 lbs. linseed cake.
   5 lbs. barley meal.
   2 lbs. bran.
   $A_{18}O_{5 \cdot 5}F_{7 \cdot 2}$.
3. 2 lbs. decorticated cotton cake.
   3 lbs. bran.
   4 lbs. ground oats.
   2 lbs. maize meal.
   $A_{17 \cdot 5}O_{6 \cdot 8}F_{7 \cdot 9}$.
4. 2 lbs. soya-bean cake.
   3 lbs. dried brewers' grains.
   3 lbs. sharps (coarse middlings).
   3 lbs. barley meal.
   $A_{20}O_6F_{8 \cdot 8}$.
5. 4 lbs. bean meal.
   3 lbs. dried grains.
   4 lbs. maize meal.
   $A_{18 \cdot 4}O_{4 \cdot 3}F_{7 \cdot 6}$.
6. 4 lbs. gluten feed.
   2 lbs. malt coombs.
   3 lbs. rice meal.
   2 lbs. maize meal.
   $A_{18 \cdot 8}O_{5 \cdot 6}F_7$.
7. 2 lbs. soya-bean cake.
   2 lbs. palm-nut cake.
   4 lbs. barley meal.
   3 lbs. maize meal.
   $A_{18 \cdot 2}O_{6 \cdot 2}F_{7 \cdot 3}$.
8. 2 lbs. gluten meal.
   2 lbs. cocoa-nut cake.
   3 lbs. bran.
   4 lbs. ground oats.
   $A_{19}O_{5 \cdot 8}F_{8 \cdot 2}$.

[1] Farmers who wish to make similar concentrated mixtures up should refer to special table of analyses on p. 206.

Rations 1, 3, 6, 7, and 8 would be very suitable for butter production as well as for cheese, while rations 2, 4, and 5 may be used for cows when the new milk is sold. Rations 1, 2, 4, and 5 would go well with hay as the fodder crop, and rations 3, 6, 7, and 8 with straw.

Comparison with Kellner Standards.—If one takes the above rations for a cow 800 lbs. live weight, yielding 3 galls. of milk per day, and includes the bulky part of ration, say, 17½ lbs. hay and 30 lbs. swedes, one can compare them with the Kellner standard, which requires 2·2 to 2·5 lbs. digestible albuminoids and 11·8 to 13·9 lbs. starch equivalent per day (see p. 129).

Taking the figures from table on pp. 48 to 51, the result would be as follows:—

Ration.	Digestible Albuminoids.	Starch Equivalent.
1	2·095 lbs.	14·275 lbs.
2	2·725 „	17·085 „
3	2·290 „	14·310 „
4	2·370 „	14·350 „
5	2·270 „	14·610 „
6	2·200 „	14·820 „
7	2·280 „	15·420 „
8	2·430 „	14·550 „

No. 1 is a little too low in albuminoids and No. 2 too high in albuminoids and starch equivalent. The remainder conform to the Kellner standard for albuminoids, and are sufficiently near in starch equivalent, although they are all slightly higher than necessary according to this standard.[1]

[1] In practice, excessive accuracy in weighing and feeding is impracticable. With a fairly long experience of advisory work, the author finds the approximate method as effective in practice as any other method—generally more so.

PLATE XXV.

Photo, Messrs. R. A. Lister & Son, Dursley, England

b. "Lister" Milking Machine.

The "Lister" is the very latest British milking machine on the market, and is giving great satisfaction to the many farmers who are using it (p. 214).

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If concentrated food is required in the summer months when the cow is out at pasture, the same standard may be taken, but the amount required per head would only be one-quarter to one-half of the above rations. When pasture grass is sufficiently abundant and of fairly good quality, it is doubtful whether it is remunerative to give cows any concentrated food, as they stand about the gate when they should be grazing. In the Offerton Hall experiments Professor Brynner Jones reports (1907) that "cows receiving nothing but grass gave relatively a much more profitable return than those supplied with concentrated food; in fact, the milk cost double to produce in the latter case as compared with the former."

In town dairies in summer, the cows receive forage crops such as rye grass, oats and vetches (green), etc., along with cake, bean meal, bran and wet brewers' grains. Brewers' grains appear to have considerable influence in keeping up the supply of milk as the lactation period advances.

If the pasture grass in early spring tends to scour animals, it would be wise to give a little Bombay cotton cake, which has a considerable "binding" effect.

XXVI. THE ART OF MILKING.

It is a good plan to tie the hind legs of a heifer together with a strap each time she is milked for the first few weeks after calving, as it trains her to stand with her feet together, with the result that she is much better to milk.

Milking the cows with dry hands is much to be preferred to milking with wet hands, as the latter method is apt to get dirt into the milk pail.

Milking should be carried out quietly, quickly, and

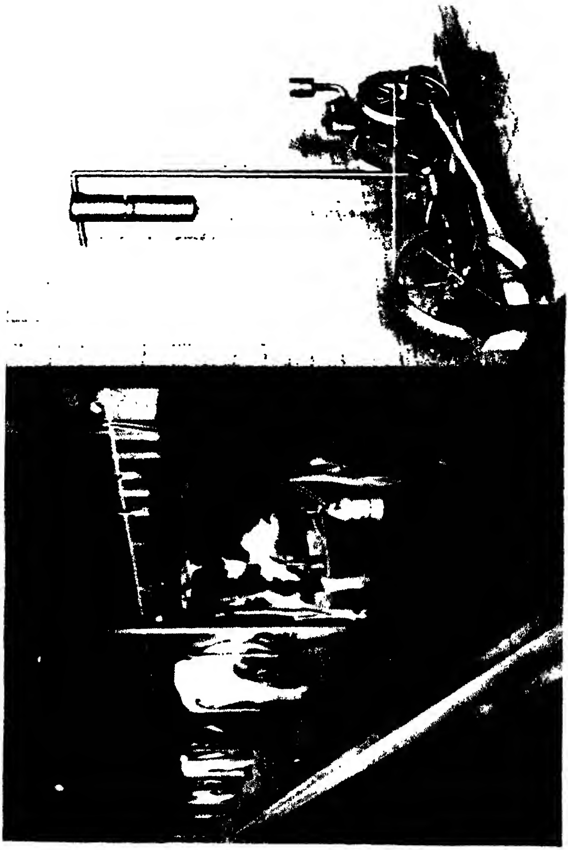
thoroughly. If the whole of the milk is not removed from the udder each milking time, the yield will very soon go down, and the richest milk be left in the udder. In the Hegelund system of milking, most of the milk is removed by hand in the ordinary way; the milker then commences to massage the udder, so as to force the milk gently into the milk cistern in the udder. After this is done, the remaining part of the milk is removed from the udder. The milk-yield can certainly be increased a little by this method, but it is doubtful if the increased yield will pay for the extra trouble.

The usual system of milking cows is to commence on the two fore quarters, and when most of the milk is removed from them, to milk the two hind quarters. It is quite natural to commence on the fore quarters, as it is the easiest way, but the tendency of constantly adopting this method of milking is to make the hind quarters larger and more capacious than the fore quarters.

The explanation is, that shortly after one commences milking, the cow begins to let her milk come; this gorges the hind quarters and expands them day after day, with the result that this continual internal pressure gradually enlarges the hind quarters. In the fore quarters the milk does not get much chance to enlarge them, as it is being removed all the time the cow is letting it down, hence they do not develop in many cases to the same extent as the hind quarters. The way to remodel such an udder is now obvious, for what is necessary in such cases is to commence milking on the larger quarters each time, so as to give the milk a chance, after the cow lets her milk down, of expanding the smaller quarters.

Machine Milking.—Shortage of labour has forced the attention of many farmers to milking machines, who are impressed by the state of perfection attained by

PLATE XXVI.



[*To face p.* 215.

the modern machine. By the aid of suction, pulsators, etc., the natural method of milking is very closely imitated, hence cows and heifers take kindly to it.

Generally speaking, machines collect the milk in cans, which receive the milk from one cow (single-can system) or two cows (double-can system). Cans may, however, be dispensed with by installing the "Automatic Receiver System," which leads the milk through tin-lined pipes direct to the dairy. The engine driving the machine may further be used for the supply of electric light in the cowhouse, etc.

Clean-Milk Production.

So far as the "New Milk" trade is concerned, there are three things which tend to discourage its increased consumption by human beings, viz.:—

1. Presence of sedimentary matters.
2. Tendency in hot weather to rapid souring.
3. Being a perfect food, it is a medium in which certain bacterial diseases may be spread, where the milk has been carelessly handled under bad conditions.

The object of clean-milk production is to secure a milk which is free from sediment, has a "long life," and is perfectly safe for infants, and the methods to be adopted will be explained later.

Producing a Safe Milk Supply.—The following methods have been adopted:—

1. Sterilisation.—In this case, the milk is heated up to the boiling-point of water (212° F.), and kept at that temperature for at least 10 minutes. It is then cooled down as fast as is practicable to avoid cracking the bottles, to a temperature of, say, 50° F. Efforts were made at the end of last century to popularise this

method; but it was found that infants did not thrive on it, and on this account it had to be abandoned as a food for infants. This process undoubtedly killed all germ life in the milk, including the spore forms, and from this point of view was safe; but the flavour of the milk was spoiled, and its food value had been deteriorated in the process.

2. **Pasteurisation.**—This method derived its name from the late Louis Pasteur, who made several important discoveries as to the control of fermentative changes by means of heat, although it appears Pasteur did not devise any particular method for treating milk. The method consists in heating milk up to a temperature of 140° to 160° F. and maintaining it at this temperature for, say, 20 to 30 minutes. It is then cooled down immediately to, say, 50° F. It has been demonstrated that this treatment is more effective when the milk is agitated during the heating process.

The effect of this treatment is to destroy the lactic acid or souring organisms in the milk, as well as any pathogenic germs which had got into the milk. In some cases the "spore forms" of certain pathogenic germs may escape destruction. At the same time the flavour of the milk is not very seriously injured, although its nutritive properties are somewhat adversely affected, and the cream does not rise so well to the surface.

Its two main recommendations are that the milk has been given a "longer life" and is safe from pathogenic germs. The bulk of the factory milk sent to London has been pasteurised; and although fairly suitable for adults, it does not appear to be so satisfactory for infants as the natural milk. It does not appear possible to heat milk at all without reducing its nutrient value. The physical and chemical effects of heating milk have been known for many years; but the

effect of heat on the newly discovered vitamins has been known for a few years only.

8. "Clean-Milk" Production. — It has been fully demonstrated in recent years that milk may be given a sufficiently "long life," and be quite sweet for human consumption without being pasteurised or sterilised. It is largely a question of methods, which are summed up in what is generally called "Clean-Milk Production."

Briefly stated, there are four golden rules which are necessary in the production of a safe and clean milk of long-keeping quality; these are as follows:—

(1) Healthy cows.[1]

(2) All dairy utensils coming in contact with the milk must have been properly cleansed and sterilised before use.

(3) Keep dirt from getting into the milk during milking and handling, seeing you cannot take out, by straining, any dirt that has got dissolved in the milk.

(4) Cool the milk immediately after milking and as low as possible (*i.e.*, 55° F. or lower).

These four rules are very far-reaching, and in most cases will need fuller explanation as to how they can be carried out.

Cleansing Dairy Utensils.—

(*a*) Rinse out cans, etc., immediately after using with *cold* water, as hot water hardens the milk and tends to fix it on the utensils in the form of a brownish hard substance.

[1] Milk from cows with infected udders should be discarded. For precautions required for production of "Graded" milks, see below.

Quarters giving abnormal milk can often be discovered by the brom-creosol test-paper method discovered by Major Golding, National Institute for Dairy Research.

PLATE XXVII.

A Devon Cow in Mr Loram's Herd, clipped on Hind Quarters, Udder, and around Udder, to facilitate clean-milk production.

[To face p. 218.

(*b*) Clean the utensils by thorough scrubbing with hot water and soda; then rinse with clean water.

(*c*) Steam the utensils in a steam box. See that the temperature of steam rises to at least 210° F., and keep at this temperature for, say, 10 to 15 minutes. Turn off steam, then open lid of steam box to let steam away, and as soon as utensils are dry, close up lid again and leave utensils in box till required again.

A steam box for above purpose need not be expensive; in fact, several farmers have home-made steam boxes which work excellently. In the Bucks clean-milk competitions of 1924, the county championship was won by Mr Wm. Culley, Maidsmoreton, who installed a home-made steam plant at a cost of £3, 10s.

Where steam is not available, finish off with *boiling hot water*,[1] and store cans, etc., mouth down till ready for use in a clean dairy, which is as far removed as possible from strong smells that would taint the utensils.

Keeping Dirt out of Milk.—A number of points are involved under this heading, viz.:—

(a) *Cowhouse.*—This should be kept as clean as possible. Cesspools should be outside the cow-house.

(b) *The Cow.*—Clip off long hair on udder, and parts surrounding udder, as well as long hair on thighs and tail where dirt tends to collect. Before milking, brush off any loose hairs, etc., from udder and any parts round about where hairs, dust, etc., may fall into the milk pail; wash the udder and teats with clean water; wipe the udder with a clean damp cloth before milking.

[1] In the Bucks Clean-Milk Competitions, with effective steaming, the milk kept for a minimum of two days; whereas, without steam, the milk only kept for a maximum of two days, and sometimes arrived sour.

(c) *Foods.*—Any strong flavoured foods, or those calculated to raise a dust, should not be fed before milking, but immediately after.

(d) *The Milker.*—He should wash his hands before milking each cow, and use a clean stool, otherwise his hands become tainted. The first stroke or two of milk from each teat should be milked on the ground, or into a pail kept for the purpose.

(e) *Best kind of Milking Pail.*—The most effective kind of pail to use has the top covered over as much as possible during milking, so as to prevent any stray hairs, etc., falling into the can. All seams of dairy utensils should be well soldered so as to facilitate effective cleaning.

(f) *Carrying Pails.*—These should have simple lids fitted, so as to keep the carrying pails covered, and so prevent any dust from falling in. The lid should only be removed when milk is being poured in or out.

(g) *Strain the milk* without delay through a good cotton-wool strainer, so as to remove any possible sediment, hairs, etc., which may have fallen in, and to find out if the cows have been properly cleaned before milking.

Cooling the Milk.—The milk should be cooled down as low as possible, say 50° F. or lower, and as soon as possible after milking, in order to check the development of any bacteria in the milk. Wherever possible, the cooling-room should only be used for cooling the milk, storing full churns of milk till sent off, as well as clean cans, seeing that milk readily takes up taints as it passes over the cooler. Unfortunately, many coolers are difficult to clean, and dirty coolers

are a prolific source of trouble to persons who are attempting to produce a long-keeping milk.

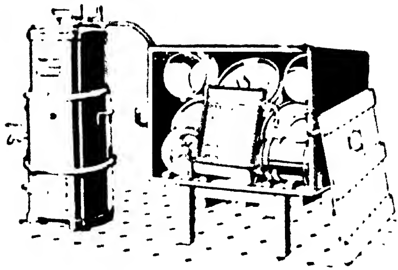
Many persons believe that expensive buildings are necessary for clean-milk production; but clean-milk competitions have demonstrated again and again that excellent results can be obtained with very ordinary farm buildings. The important thing is that cleanly methods are adopted at every stage where the milk is handled on the lines mentioned above, and no matter how elaborate the buildings may be, clean milk will not be produced unless cleanly methods are adopted. At the same time, well arranged buildings and good floors make it easier, other things being equal, to obtain good results.

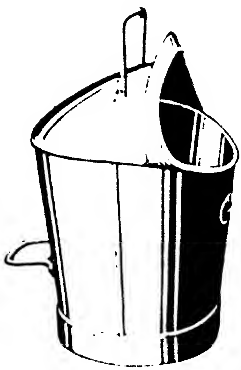
It is quite easy to spend money ineffectively in adapting existing buildings for clean-milk production, and generally speaking, this can be avoided by consulting an expert such as the County Agricultural Organiser or County Dairy expert before spending any money in this direction.

Graded Milks.

Under Section 3 of the Milk and Dairies (Amendment) Act of 1922, the designations "Certified Milk," "Grade A (Tuberculin Tested)," "Grade A," etc., may only be used where a licence to sell milk under these designations has been granted by the Minister of Health or other competent authority. Licences are required by the producer as well as by the person who sells it. The main provisions in these "graded" milks are as follows:—

(a) *Certified Milk.*—A register of all animals in the herd is to be kept. Cows must pass the tuberculin test before a licence is obtained, and thereafter at intervals of six months. The herd to be inspected every three months by an approved veterinary surgeon.





Milk must be bottled on the farm and sealed with suitable caps, which bear the name and address of the producer, the day of production, and the words "CERTIFIED MILK."

The milk prior to delivery to the consumer must not contain *Bacillus coli* in $\frac{1}{10}$ c.c., and must not contain more than 30,000 bacteria per c.c. The farmer must keep records of all milk produced and sold, as well as the names and addresses of purchasers. The distributor likewise must keep records of milk purchased and sold. The Licensing Authority has power to inspect the premises to see that the above requirements are being carried out, take samples of milk, etc.

The licences in this case must be obtained from the Minister of Health so far as the producer is concerned, and from the District Council so far as any other dealer or distributor is concerned.

(b) *Grade A (Tuberculin Tested)*[1] *Milk.*—The conditions are very similar to those for certified milk, except that the milk may or may not be bottled on the farm, must not contain *Bacillus coli* in $\frac{1}{100}$ c.c., nor more than 200,000 bacteria per c.c., and further that the sealed cap of the bottled milk contains the designation "Grade A (Tuberculin Tested) Milk" in place of Certified Milk. In cases where the milk is bottled off the farm, it must be conveyed from the farm to the person bottling same, in unventilated sealed containers, bearing a descriptive label with address of farm, day of production, and the words "GRADE A (Tuberculin Tested) MILK."

The Licensing Authority is the Minister of Health for the producer, and the District Council for all other dealers.

[1] Unfortunately a cow that has been recently tested may not react to the tuberculin test. It is therefore important for those who purchase cows on the test to satisfy themselves on this point; otherwise disappointment and loss may be the result.

(c) *Grade A Milk.*—The conditions are very similar to those for Grade A (Tuberculin Tested) Milk, except that the cows need not be tuberculin tested; but where tubercle bacillus is found in the milk, the affected cows must be identified and removed.

The Licensing Authority for the producer is the County or Borough Council, as the case may be, in which the milk is produced, and for any other dealer or distributor, the District Council. Where a farmer retails his milk, he can get an inclusive licence as producer and distributor.

(d) *Grade A (Pasteurised) Milk.*—This is applied to any Grade A milk, except that it has been pasteurised for at least 30 minutes at a temperature of 145° to 150° F., and immediately cooled to 55° F. or less, does not contain *Bacillus coli* in $\frac{1}{10}$ c.c., nor more than 30,000 bacteria per c.c. Further, the vessels containing it must be suitably labelled with the day of pasteurisation and designated "PASTEURISED MILK."

The Licensing Authority for the distributor is the District Council in which the pasteurising premises are situate.

XXVII. COST OF PRODUCING MILK, KEEPING DAIRY COWS, ETC.

Dr Crowther shows in his second report (1913) the average cost of producing milk throughout the year, *when the food only is taken into account.* This varied very considerably; in fact, some of the cows produced milk at half the cost of others under observation.

In the following summary the hay is taken at 55s. per ton; oat straw, 30s.; barley straw, 25s.; swedes, 10s.; mangels, 10s. 6d.; and turnips, 8s. per ton; grass, 3s. 6d. per week; concentrated foods at cost price.

Out of 204 cows included in the report, the average cost of food to produce a gallon of milk is seen to vary greatly, for—

Cows.		Estimated cost per gall.	Cows.		Estimated cost per gall.
21	produced milk at	10d. or over	36	produced milk at	7d. to 8d.
7	" "	9d. to 10d.	42	" "	6d. " 7d.
15	" "	8d. " 9d.	83	" "	less than 6d.

The cost of producing milk per gallon is naturally much less in the summer than in the winter months. If the cows are getting nothing more than pasture grass, the cost may be reduced to about one-half that in the winter months. If concentrated foods are required in addition to grass, the cost will be increased to two-thirds or even three-quarters that of winter milk.

The above figures show the necessity of selection in the dairy herd, if milk is to be produced economically.

Cost[1] of Keeping Dairy Cows.

This varies according to the time of year the cows calve. *E.g.*:—

Approximate Cost per Annum of Keeping a Cow.

March Calver.

	£	s.	d.
Twenty-two weeks' grazing in summer, May to October—1½ acres, at £1, 5s.	£1	17	6
Bombay cake fed while on grass – 2 lbs. per day 3 cwts., at £4, 15s. per ton	0	14	3
Cake and meals during usual milking period—6½ cwts., at £7 per ton	2	5	6
Oat straw (part long, part chopped), 1 ton, at £1, 5s., produced on the farm (consuming value)	1	5	0
Hay, 1 ton, at £2 per ton (consuming value)	2	0	0
Roots, 5 tons, at 9s. per ton (consuming value)	2	5	0
TOTAL COST OF FOOD	£10	7	3
Attendance, at aver. of 9d. per week	2	10	0
Vet., say 5s.	0	5	0
	£12	12	3

Risk may be put at £1 to £1, 10s., and depreciation would have to be considered in some cases.

[1] The cost of purchased feeding stuffs (1924) should be increased by approximately 50 per cent.

October Calver.

October till May (thirty weeks), following ration:—

Swedes, 56 lbs. per day = 5¼ tons, at 9s. . .	£2	7	3
Hay, 14 " " = 26 cwts., at £2 . .	2	12	0
Straw, 7 " " = 13 cwts., at £1, 5s. . .	0	16	3
Decorticated cotton cake, 2 lbs. / Bran, 2 lbs. . . / Maize meal, 3 lbs. . / Pea meal, 1 lb. . . } 8 lbs. per day = 15 cwts., at £7 per ton .	5	5	0

June to September (twenty-two weeks):—

Grazing = 1½ ac., at £1, 5s. per acre . . .	1	17	6
Bombay cake, 2 lbs. per day at grass . . .	0	14	3
TOTAL COST OF FOOD . . .	£13	12	3
Attendance, at 1s. per week	2	12	0
Vet., say 5s.	0	5	0
	£16	9	3

Risk may be put at £1 to £1, 10s., and depreciation would have to be considered with some cows.

Returns[1] from Milk-Selling per Cow per Year.

March Calver.

500 galls. milk, at 8d. per gall. (summer) .				£16	13	4
150 galls. " 10d. " (winter) .				6	5	0
				£22	18	4
Less carriage on rail, at ½d. per gall. . . .	£1	5	0			
Less cost of food, etc., as above . . .	12	12	3			
				13	17	3
Balance in favour of March Calver .				£9	1	1

[1] The farmer's price for milk (1924) should be increased by approximately 50 per cent.

October Calver.

500 galls. milk, at 10d. per gall. (winter) .			£20 16 8
150 galls. „ 8d. „ (summer) .			5 0 0
			£25 16 8
Less carriage on rail, at ½d. per gall. . .	£1 5 0		
Less cost of food, etc., as above . . .	16 9 3		
			17 14 3
Balance in favour of October Calver .			£8 2 5

These estimated results appear to show that the balances to be obtained by winter milk production as compared with milk produced mostly during the summer months of the year, are approximately the same. In arriving at these results, it has been assumed that a spring calver gives the same amount of milk as an autumn calver, but is this so? The following results will shed light on this point.

In some trials carried out by the Irish Department of Agriculture, Mr Adams gives the following interesting comparisons of November and April calvers. There were five cows in each lot, records being kept in the case of the November calver for the twelve months, Nov. 1907 to Nov. 1908. In the same way the records of April calvers were kept from April 1908 to April 1909. A few results selected from the report are as follows:—

November Calver.	*April Calver.*
Average yield of milk for year, 836 galls.	Average yield for year, 678 galls.
Average cost of food for year, £12.	Average cost of food for year, £10, 3s. 0d.
Total cost of keeping cows for year averaged £21, 17s. 2d.	Total cost, £17, 4s. 3d.

November Calver.	*April Calver.*
Yielding $1\frac{3}{8}$ galls. of milk on an average at the end of tenth month.	Only giving this average up to end of eighth month.
Gave 20 galls. milk or more each per week for twenty-seven weeks.	Gave 20 galls. milk each per week for thirteen weeks only.
When turned out to grass in spring, milk-yield showed an increase.	Not much effect.
Highest yield in Dec., Jan., Feb., and March, when milk is dear.	Highest yield in summer when milk is cheap.
Balance, after allowing for rent, taxes, insurance, depreciation, milking, and delivering milk, etc., was £4, 6s. 2d.	Balance left was only £1, 16s. 1d.

It appears from the above results that winter milk is quite as profitable as that produced in summer, provided the cows produce at least 650 galls. milk per year, and sufficient home-grown foods are raised to provide the bulk of the ration for winter feeding.

The November calvers yielded on an average 158 galls. of milk more than the April calvers, which is a very striking point in these trials.

Comparing the Different Systems of Dairying.

Supposing cow commenced milking in the spring-time:—

1. *Milk Selling*—

Summer months—500 galls. milk, at 8d. per gall.	£16	13	4
Winter months—150 galls. milk, at 10d. per gall.	6	5	0
	£22	18	4

2. *Buttermaking* (2½ galls. Milk to 1 lb. Butter)—

	£	s.	d.
260 lbs. of butter, at 1s. 2d. per lb. . . .	£15	3	4
285 galls. separated milk, at 1d. . . .	2	8	9
39 galls. buttermilk, at 1d.	0	3	6
	£17	15	7

3. *Cheesemaking* (1 gall. Milk to 1 lb. Cheese)—

(Say 550 galls. made into Cheese, and 100 galls. made into Butter.)

	£	s.	d.
550 lbs. cheese, at 6½d. per lb. . . .	£14	18	0
468 galls. of whey (85 per cent. of milk taken), at ½d. per gall.	0	18	0
41⅔ lbs. butter, at 1s. 2d. per lb. . . .	2	8	6
90 galls. separated milk, at 1d. per gall. . .	0	7	6
6 galls. buttermilk, at 1d. per gall. . . .	0	0	6
	£18	12	6

Score Card for Dairy Shorthorn Cow.

The score card on p. 228 has been drawn up by the writer for use by the students in connection with the Winter School of Agriculture at Hereford.

XXVIII. BEEF CATTLE.*

The fattening of beef cattle plays a very important part on arable farms, seeing that it is, after all, one of the most convenient ways of dealing with the bulky produce (straw and roots chiefly) grown on the farm. A further consideration is the production of large quantities of manure, which is so valuable for maintaining the fertility of arable land. In fact, big crops and heavy cattle-feeding usually go together on farms in this country.

Generally speaking, the eastern half of Great

	Max. Points.
General Appearance, 22 points—	
1. FORM—Wedge-shaped when viewed from top as well as from side. Underline inclining downwards from fore-end to flank	8
2. TEMPERAMENT—Active, but quiet to handle	4
3. QUALITY—Skin yellowish in colour, soft, moderately thin, very flexible, and elastic	10
Head and Neck, 10 points—	
4. HEAD—Feminine. Horns free from coarseness and slightly yellow at base; face moderately long; eyes bright, prominent, and wide apart; nose broad between nostrils	6
5. NECK—Fairly long, fine at junction with head, and sloping gradually on to shoulders	4
Fore Quarters, 8 points—	
6. SHOULDERS—Not prominent, fairly light, sharp on withers	8
Body, 16 points—	
7. CHEST—Fairly deep, giving sufficient room for heart and lungs. Well filled up behind shoulder	6
8. BACK AND LOIN—Back moderately long and straight. Loin broad, strong, and level	5
9. RIBS—Moderately well sprung and long, giving deep body	5
Hind Quarters, 14 points—	
10. QUARTERS—As long and as wide as possible; hook-bones wide apart, but not too prominent; pin-bones fairly high, and wide apart	8
11. TAIL—Long, fine, set on level with back	2
12. THIGHS—Sinewy, long, thin, and well bent	4
Udder, 25 points—	
13. CAPACITY—Should extend well forward and backward, be capacious and symmetrical	10
14. QUALITY—Skin flexible, elastic, and free from fleshiness. Hair on udder silky	5
15. TEATS—Medium size, uniform, and placed fairly well apart. Milk easy to draw	5
16. MILK VEINS—Large, prominent, well branched, with well-defined milk-wells	3
17. ESCUTCHEON—Spreading wide over thighs, extending high and wide, with large ovals or tufts on thighs .	2
Legs, 5 points—	
18. Not too long; bone free from coarseness	5
	100

ESTIMATED WEIGHT . . . . cwts.
AGE BY TEETH OR HORNS . . . . yrs.

PLATE XXIX.

Britain is largely devoted to arable farming and stock fattening, while the western half is more noted for its grass-land and dairy farming; consequently it is in the eastern half of England and Scotland that one expects to see the house-fattening of cattle carried on to the highest pitch of perfection, and in the western half to find the best examples of grass-fattening of cattle, as in Herefordshire and similar counties.

Type of Animal required.—It is essential to know what are the outstanding points of a typical animal for beef production, so as to enable one to breed or buy store, a type that will give a good account of itself.

The chief points are as follows:—

Head.—Neat, and not too large. Forehead broad between eyes, and nostrils wide apart.

Neck.—Clean cut at throat, and sloping gradually on to shoulders.

Shoulders.—Not prominent along shoulder-blades, well covered with flesh, and sloping gradually on to barrel.

Body.—Well filled up behind shoulders. Ribs well sprung and long, giving deep sides. The underline should be straight, and the flank come well down.

Back.—Straight and broad, with a strong loin.

Hind quarters.—Should be as long and as square as possible. Hook-bones should not be prominent, and the line from the hooks to the shoulders along the arch of the ribs should make a very gentle curve.

Thighs.—As well developed as possible, well fleshed down to the hock, giving a good second thigh and twist.

Legs.—The bones of legs should be free from coarseness.

Breed and Quality.—It is further important that animals for fattening purposes should be of a breed or cross which is noted for its capacity to fatten, as experience shows that a well-bred animal will generally pay to feed, while inferior bred ones often prove disappointing. The skin should be fairly thick but flexible, and the whole body in fat animals covered as uniformly as possible with flesh. When fat, patchiness is very undesirable.

Early maturity is very important, and beasts should as a rule be selected which will grow and thrive at the same time.

Available Breeds.[1]—The most generally known breeds in this country are:—

Polled Breeds.—Aberdeen-Angus, Red Polls, Galloways, etc.

Horned Breeds.—Herefords, Shorthorns, North Devons, West Highland, Welsh cattle, etc.

The outstanding features of these breeds are as follows:—

Aberdeen-Angus.—Found chiefly in the east of Scotland; large black cattle—mature early; short legs, carrying an enormous shapely body which is generally evenly covered with flesh; meat of excellent quality. They are very hardy and do well in poor, exposed districts. At the same time they can adapt themselves to heavy hand-feeding in cattle courts, and give good return for the food consumed.

[1] For full description of the various breeds of cattle, see Prof. Wallace's *Farm Live Stock of Great Britain*.

Red Polls.—Located chiefly in the south-eastern counties of England. Have much in common with Aberdeen-Angus, but are red instead of black in colour.

Galloway.—Common in the south-west of Scotland. Polled black cattle, not so large as Aberdeen-Angus. The coat is generally fairly long and shaggy, often with brownish tinge on tips of hair. Differs from Aberdeen-Angus in having a flatter poll (A.A. peaked); ears larger, placed farther back on head, and usually carrying a long fringe of hairs on edge of ear. Its bones are not quite so fine, or its skin so thin. Does not mature so early, but can thrive on second-rate land. Produces an excellent quality of beef.

Herefords.—Confined largely to Herefordshire and adjoining counties in England. Have characteristic white faces and red-coloured bodies with patches of white along the underline. These are big, hardy cattle, which mature early, and thrive on grass-land. They are typical grazier's beasts, and are splendid "hustlers." Quiet, docile, and fatten readily, giving a carcass of first quality meat. They are said to require much less water to drink than, say, a Shorthorn.

Shorthorn.—Widely distributed over the British Islands. Vary in colour from reds, roans, to whites. Large, horned cattle, and mature early. The beef (Booth) type fatten readily. As a rule, more prominent on hook-bones than above-mentioned breeds. Require fairly heavy hand-feeding, and then yield a very fine class of beef.

North Devons.—Mostly found in the south and south-west of England; reared chiefly in Devon and Somersetshire. Medium sized, red in colour, and horned cattle with short legs and compact bodies. Their symmetry is perfect. Graze well on the second-rate pastures of their native hills, and turn their food to good account. The quality of their flesh is such that it commands a very high, if not the highest price, in the London market.

West Highland.—The name indicates the part of Scotland where they are most commonly found. They are horned cattle with long, shaggy coats. The colour of their coat varies from light dun, tawny yellow, to black. Very hardy; thrive on very scant herbage. Slow maturers, but when fat yield meat of the finest quality.

Welsh Cattle.—Found mostly in North Wales. They are black, horned cattle which thrive very well on hilly pastures. Mature early, and give a good quality meat.

Although the pure breeds do splendidly for beef production, feeders are generally well satisfied if they can get a suitable first cross of the above-mentioned breeds; in fact, for commercial beef cattle, the first crosses are exceedingly popular.

The following are popular crosses:—

Aberdeen-Angus × *Shorthorn.*—Generally black, and polled. Responds to heavy feeding. Favourite cross at Smithfield Show.

Hereford × *Shorthorn.*—Mostly white faced. A splendid cross. Fattens readily.

Shorthorn (*White*) × *Galloway*, called *Blue-Greys*—Blue-grey colour, and polled. Favourite cross in north England and south Scotland.

Hereford × *Galloway*.—These are generally white faced, and polled. Hardy cross, and ready fatteners.

Aberdeen-Angus × *West Highland*.—Generally black, and polled.

Shorthorn × *West Highland*.—Horned, and generally Highland type.

Dairy farmers are not slow to meet the demand of the "feeders" for young calves, hence they cross their Shorthorn dairy cows with an Aberdeen-Angus or a Hereford bull. In like manner the Ayrshire dairy cows are crossed with Aberdeen-Angus or Galloway bulls. The result is that the bullocks of these crosses fatten fairly well, while the heifer calves later on make splendid mothers, as their milking qualities have been improved by the cross. If crossed again with, say, a Shorthorn or other breed of the beef type, they give a second cross which is an excellent class for early beef production.

How the Feeder secures his Animals.—There are, generally speaking, three ways adopted by feeders in securing the necessary animals for fattening purposes.

1. Breed them. This is a capital way when "early beef" is required.
2. Buy calves a week or two old: This is a common method on highly rented land where a cow has to rear several calves.
3. Buy store cattle at about fifteen to eighteen months old, as practised on arable farms.

XXIX. FATTENING OF CATTLE.

(a) Baby Beef Production.

"Baby beef" refers to cattle which are sold fat at an age of fourteen to twenty-two months, and a live weight of approximately 7 to 9 cwts., 56 to 60 per cent. of which would be carcass. Literally speaking, the carcass is the "baby beef," and it is noted for being very juicy, tender, and of excellent flavour. The proportion of lean meat to fat is also comparatively high, and, on account of its juicy qualities, is more acceptable to the public palate, consequently a higher price can be realised for it, and, what is of further importance from the business point of view, the increase can be produced at a lower cost than with animals two years old or upwards. In other words, 1 cwt. of increase in live weight can be obtained with less food in the former case than in the latter.

For baby beef the calf is liberally fed from birth onwards, concentrated foods being used as far as is necessary in addition to milk while the cow is suckling the calf. After weaning, the cake is gradually increased with the age of the calf until it is fat.

The calves may be either bred or bought for this purpose, and reared on one of the following systems:—

1. First cross heifers.—Hereford × Dairy Shorthorn, Red Poll × Dairy Shorthorn, Aberdeen-Angus × Dairy Shorthorn, Aberdeen-Angus × Ayrshire, or Galloway × Ayrshire may be purchased and mated with, say, a Shorthorn of the beef type. The calf obtained has very much in common with a first cross from two beef breeds, and in addition has the advantage of being suckled by a cow which is a good milker,

on account of having been crossed with a milking breed.

The cow suckles her own calf only, and does it wonderfully well. In the spring, cow and calf are out at grass, and if the grass is not abundant, the cow will require some concentrated food and possibly hay. The calves will soon learn to eat concentrated food with their mothers, and should have any deficiencies in the quantity of milk from the cow made up with cake, at the rate of, say, 1 lb. for every 100 lbs. live weight, so as to keep them growing and thriving as rapidly as possible up to the time they are sold fat during the following year. The animal at eighteen months old may then realise 44s. per live cwt., or, say, £18, which is a good price for a fat animal at this age.

2. The following system is adopted on rich pasture-land where the cow and calf are fattened off together, more especially when the cow is not intended to breed again. Hereford cows, N. Devons, or crosses between these and other beef breeds, are timed to calve about March. The cows may or may not be good milkers, but help the calf on very considerably for a time. The cow receives, say, 4 lbs. decorticated cotton cake per day, with the result that she fattens rapidly and may be sold off prime fat about July, when the calf is about four months old. The cow is then sold, and the calf is liberally fed with concentrated food during the autumn, winter, and following spring months. It is summered a second season, and then sold off at sixteen to eighteen months old, at a live weight of about 8 cwts.

3. A third system is sometimes adopted on good land, of buying heifers due to calve about March. Allow them to suckle own calf for, say, five weeks, when calf is sold off for veal at probably £4. In May

give heifer a couple of calves to rear, tied together with neck straps and a chain about a yard long, and allow her, if necessary, up to 4 lbs. cotton cake per day. Calves are then weaned about end of January or in February. Feed calves liberally with cake, and sell off fat in May at fourteen or fifteen months old.

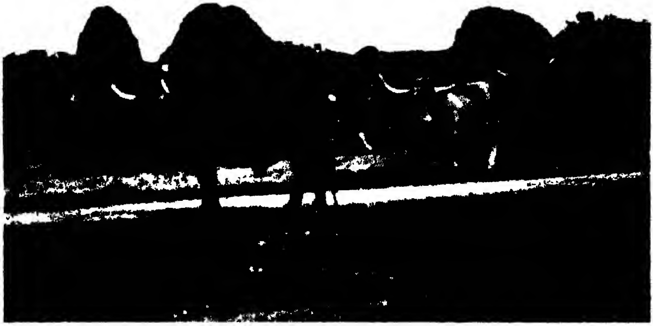
(*b*) Fattening Cattle in Summer at Grass.

This is a very good and easy way of producing beef, and may be adopted more especially on moderately rented land. Two very good systems are as follows:—

1. Bullocks may be reared as cheaply as possible up to two years old on grass in summer, with straw and turnips in winter. The following summer they would in many cases receive some cake to hasten the fattening process, so that they may be sold fat from the grass-land.

2. Store cattle may be bought at twelve to eighteen months old in the autumn or spring. These would be wintered cheaply on straw and roots, then fed off during the following summer on grass and cake. If a bullock increases in value at grass at the rate of 10s. or more per week, it is giving a very good account of itself.

An interesting experiment was carried out at Cockle Park, in fattening bullocks at grass in summer. Yearling bullocks were purchased for this purpose at 30s. per live cwt. At the beginning of the experiment (May) they weighed on an average 5½ cwts. These were fed for twenty weeks at grass with 2 to 3 lbs. of cake per head per day, made up of three parts decorticated cotton cake and one part linseed cake. The cake, attendance (3d. per head per week), and interest (5 per

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cent.) on capital outlay, amounted to 35s. for the twenty weeks, or an average of 7s. per month.

The bullocks sold out at 34s. per live cwt., and when manurial residue was taken into account, left a margin of £6 per head over their value at beginning of experiment. Subtracting the cost of cake, attendance, etc., mentioned above, viz. 35s., the balance for grazing per bullock during the twenty weeks amounts to £4, 5s., which gives an average of 4s. 3d. per head per week for grazing these bullocks.

To put this result another way: the bullocks increased in value 24s. per month, and with grass valued at 4s. per week, they cost 23s. per month for grass, cake, attendance, and interest.

(*c*) House Fattening of Cattle.

The first thing of importance is to secure suitable cattle for house fattening, and very often it will be necessary to buy stores. In purchasing these stores one should keep in mind the following points:—

1. The cattle should have been reared on a poorer farm than that to which they are going.
2. They should be well bred (first crosses preferably), of the right type, and with good constitutions.
3. If possible, the purchase price should be at least 5s. less per live cwt. than one expects to get when they are fat, otherwise the transaction is not likely to be a commercial success.

The last point involves the use of the weighbridge, and this deserves greater encouragement. The average farmer has very little to gain by not using it, and has a great deal to lose. Few farmers would agree to sell

hay, beans, or cereal grains, potatoes, etc., without first weighing them; but it is quite as easy to estimate the weight of oats or potatoes as that of a fat bullock. The fairest way is always the best way in the long run. Good feeding should be encouraged and poor feeding discouraged, and selling by weight certainly has the desired effect. Several other countries have already adopted it, and much prefer it. Further, the frequent use of the weighbridge for bullocks, prior to and during fattening, shows up many important points which enable the feeder to ascertain which system of feeding is the most economical.

If one keeps in mind that a 7-cwt. store bullock at 30s. per cwt. comes to £10, 10s., and an 8-cwt. bullock at 30s. comes to £12, it is not difficult and very important to know, fairly approximately, what price is being paid per hundredweight for the store animal.

In Scotland and the north of England polled animals are generally preferred for "court or yard" fattening, and command a higher price, more especially because they do not injure one another with their horns in the courts or yards, and a greater number can be placed in a railway truck when they are bought or sold.

Systems of Housing.—The three chief systems of housing are—(*a*) In stalls, tied up by neck; (*b*) in loose boxes, with any number up to four together; (*c*) in courts or yards, with sometimes as many as twenty together. The advantages and disadvantages of each of these systems of housing are as follows:—

Stall Fattening.—Economises space. Each animal gets its share of food, and its progress can be more carefully watched. One can also

vary the food to suit the particular case; *e.g.*, one animal may need a more "laxative" or a more "binding" diet than another. It is very suitable for horned cattle, which might damage one another in yards, and is more economical of litter.

Loose-box Fattening.—For single animals the box would be about 10 feet square, and correspondingly bigger for a larger number of animals. It is therefore easy to see that a larger surface area of buildings will be required. The animals receive more or less individual attention, and the manure is well preserved. The bullocks would require about 14 to 21 lbs. litter per day. Such boxes are especially useful on farms where the court system of housing is practised, as individual animals can be drawn out from time to time for special fattening. In some cases there may be a small shed of about 150 sq. feet of floor space opening into a yard of similar size. This is sometimes called a "hammel."

Court Fattening. — These are called yards in England, and in some parts of Scotland the term "reed" may be used instead of court. The cost of labour in feeding a number of animals together is less than in the two previous cases, and although the larger courts, holding, say, twenty bullocks, are more convenient in the very early stages of fattening, it is a distinct advantage to be able to draw the more forward animals out and place them in smaller courts, holding, say, four or ten, for special feeding later on.

The courts or yards may be covered in entirely with a roof; or may be open, with covered feeding-sheds along one or more sides, under which the animals can go at will for food or shelter.

The covered courts are generally much warmer; in fact, sometimes too warm if arrangements have not been made for sufficient ventilation. Cattle can be fattened in them to go out at Christmas, or any time during the spring. The manure is very much better preserved, and further, it can be carted on the arable land and ploughed in immediately.

In the case of open yards, the chief advantages are that they are much less costly to construct, and give the animals plenty of fresh air. For breeding stock this is a great advantage, especially when one remembers that in Herefordshire, where this system is universally practised, their breed of cattle is almost free from cases of tuberculosis. It is a great advantage to have the sheds facing south. For fattening cattle, however, they are generally colder, and it is difficult to fatten cattle in them to sell off fat before spring. Much more litter is required to keep the yards clean, and the manure gets sadly depleted of its valuable constituents except in dry frosty weather. The manure has absorbed considerable quantities of water, and requires much more carting out. It is further necessary to cart the manure into a large heap, so as to allow it to ferment somewhat before ploughing it into the land. The farmyard is always very difficult to keep clean and tidy where there are open yards.

The advantages of covered courts over open yards for fattening bullocks during the five or six months they are kept in them in winter, have been estimated

PLATE XXXII.

[illegible]

[illegible]

[illegible] p. 241.

at approximately 50s. per bullock. This figure is arrived at as follows:—

	Loss per Bullock.
Extra carting of manure and loss by washing .	£0 18 0
Extra litter required (1 ton for winter months) .	1 0 0
Extra food required to give same increase as in covered courts, 6d. per head per week, say .	0 12 0
	£2 10 0

It is important, when covered cattle courts are being built, to see that the ventilation is adequate, and that, as far as possible, advantage is taken of the sun to light up and warm the courts. Many open yards lend themselves to having a cheap roof put over, and on a long lease may even warrant the farmer doing it himself if the landlord is not prepared to go to the expense. In this way one gets the advantages of the two systems, and brings the disadvantages to a minimum.

Store bullocks would probably be bought in the autumn and put on the grass fields. They would then be given a few roots in order to accustom them to hand-feeding, and thus prepare them for the court fattening. Later on they would be brought into the courts at night and given a little cake. Towards the end of October, or during November, they would be confined more or less to the courts or yards, according to the district, and fattened off as quickly as possible.

XXX. LESSONS FROM FEEDING TRIALS, ETC.

Fodder Crops.—Oat straw, barley straw, and hay are the chief fodder crops on which the feeder has to rely in winter. These are bulky fodders which are produced on the farm, and this is one of the most convenient modes of utilising them.

In Scotland, more especially Aberdeenshire and Forfarshire, oat straw is the chief fodder crop used, and along with roots and cake gives excellent results with fattening bullocks, while in south Scotland and north of England a little hay is often given with the straw in the later stages of fattening. In the south of England the straw is very dry and woody, on account of the climate being warmer, hence hay has to be fed much more freely to fattening bullocks.

When the fodder crops are hard and of inferior quality, or are short in quantity, it will probably be found necessary to chaff it and feed along with roots and meals. In the former case the roots will soften the hay or straw, and in the latter it will enable one to make a given quantity of fodder crops keep the stock for a longer period.

The amount of fodder crops that a bullock will eat varies with the quantity of roots which it is receiving and the amount of concentrates fed. *E.g.*, in the Edinburgh College experiments in 1906, the bullocks receiving 90 lbs. roots per head per day, and straw *ad lib.* (lot. 1), consumed on an average 15 lbs. straw, while those receiving 110 to 135 lbs. roots per head per day (lot 2) consumed only 10 lbs. straw per head per day. In the same experiment, where a limited quantity of roots was fed (90 lbs.), it appears that those bullocks receiving a very heavy feed of concentrates

consumed a third less straw than those receiving a fairly heavy feed of concentrates (8 to 9 lbs. per head per day).

Experiments at Cockle Park in 1910 indicate that for fattening bullocks 7 lbs. hay were equal to 12 lbs. oat straw.

Root Crops. — These are exceedingly useful, on account of their juicy, cooling, and laxative properties. The order in which they are fed depends largely on the time of maturity as well as on their keeping properties, hence turnips are fed in the autumn. These are followed by yellows, and the yellows by swedes. In England, mangels may be substituted for swedes to a greater or less extent, as the case may be. When the leaves or "tops" are fed, they have a tendency to scour the cattle.

Opinion differs as to which is the best way to feed roots; but it is generally agreed that for young bullocks which are changing their teeth, the roots should be given in slices, as they are more easily eaten. On the other hand, butchers in the north-east of Scotland maintain that cattle fed on whole roots (break their own neeps) come out much fresher after a long and fatiguing journey to Smithfield (London) than those fed on pulped roots.

Pulping is generally adopted when the hay or straw is chaffed and mixed with pulped roots and meals. Very often a little locust-bean meal or some treacle is put into the mixture to sweeten it, and after being allowed to ferment from twelve to twenty-four hours, the mixture is fed to stock. By so doing one may expect to save about 1s. per head per week on the food bill, through chaffing and pulping.

Sliced roots have been compared with "pulped" roots in connection with the Yorkshire College bullock-feeding experiments in 1904. Two lots of four bullocks each were taken and fed on a daily ration consisting of 70 lbs. roots, 15 lbs. oat straw, and 10 lbs. concentrates; the only difference being, one lot received "pulped" roots, while the other received them sliced. The results were as follows:—

Pulped roots gave an average daily increase in live weight of	1·64 lbs.
Sliced roots gave an average daily increase in live weight of	2·07 „

These results are in favour of the roots being sliced when the same quantity of roots are fed in each case and the straw is of good quality.

It is well known that when roots are pulped or sliced for some time before they are fed to stock, that they "dry" considerably on the surface. Contrary to general opinion, they do not appreciably lose weight even after the cut roots are left for twenty-four hours (*i.e.* not more than 2 per cent.), but everyone agrees that they are not so juicy and attractive if left in this way, consequently many feeders cut the roots immediately before they are given to the cattle.

Seeing that a large proportion of the beef cattle are sold off before they are three years old, it may be concluded that where the fodder crops used are of good quality, it is best to feed the roots sliced, and to slice them as near feeding time as is practicable.

Quantity to Feed.—With regard to the most suitable "quantity" of roots to feed, this depends entirely on the nature and quality of the fodder crops and concentrated foods in the daily ration; *e.g.*, a smaller quantity is

required with hay than with straw. A smaller quantity is also required when the concentrates are of a laxative nature. Experiments conducted by the Edinburgh and East of Scotland Agricultural College in Forfarshire showed that when bullocks were receiving an average daily ration of 6 lbs. Bombay cotton cake, with straw *ad lib.*, those receiving a limited quantity of roots (90 lbs. per head per day) produced live weight increase at a cost of 49s. 9d. per cwt., while those receiving roots *ad lib.* (110 to 135 lbs.) produced their increase in live weight at a cost of 55s. per cwt. This demonstrates clearly that, with a limited allowance of cake, the daily allowance of roots should scarcely exceed ¾ cwt.

It has been stated that when roots are fed in excess they may have a depressing effect on the digestibility of the fodder crop given, but this is not likely to take effect until the allowance of roots per day has exceeded ¾ cwt., provided the bullocks receive a liberal allowance of cake. The results of this experiment apparently support the above statement.

At Woburn, in the winter of 1895-6, Dr Voelcker carried out an experiment with two-year-old Hereford bullocks, allowing on an average 8 lbs. cake per head per day along with chaff and roots. Those receiving approximately 50 lbs. roots per head per day gave an average live weight increase of 1·75 lbs. per day, while those receiving approximately 35 lbs. roots increased at the rate of 1·66 lbs. per day. When cost and manurial value were both taken into account, the advantage was still with the lot receiving 50 lbs. roots per day.

The above experiments appear to show that where roots are sufficiently plentiful, that a daily allowance of ½ to ¾ cwt. for a two-year-old bullock is a satisfactory quantity.

The *kind of root-crop* fed also deserves consideration; *e.g.*, feeding trials at the Harper Adams Agricultural College showed that 44·1 lbs. mangels were approximately equal for fattening purposes to 27 lbs. sugar beets. Generally speaking, one may assume the relative values of roots to be in proportion to the dry matter they contain.

When roots are scarce, it is necessary to substitute for them concentrated foods, treacle, etc., but experiments have not shown that an adequate substitute can be found for roots; *e.g.*, Professor Seton reported in 1904 (Yorkshire College), in connection with bullock-feeding trials, that "treacle cannot satisfactorily take the place of roots in a fattening ration." Professor Middleton also found (Cockle Park, 1903) that, with bullocks receiving 56 lbs. roots (swedes chiefly), this could not be effectively replaced by 28 lbs. roots, 2¾ lbs. seeds hay, ½ lb. maize meal, and ¼ lb. treacle, seeing that live weight increase in the former case cost 44s. 6d. per cwt., and in the latter 51s. per cwt.

Concentrates.—The basal part of the ration for a fattening bullock consists of fodder crops (chiefly oat straw) and roots, both of which are poor in nutrient constituents; and as the animal consuming these foods can only lay on flesh from the digested nutrients which are in excess of maintenance requirements, it follows that concentrated foods must be employed to raise the character of the ration, and that such concentrated foods should be used as will make up any deficiencies in the fodder crops and roots forming the basal part of ration.

The general scheme adopted is to give each bullock a small quantity (say 2 lbs.) of cake per day at the

beginning of the fattening period, and to increase this amount in both quantity and quality as fattening proceeds. At the same time the whole ration should be slightly laxative, and the selection of concentrates should be such as to bring about this desired result. When fattening begins in earnest, 1 lb. of concentrated food may be allowed for every 100 lbs. live weight of animal being fed.

Feeding Standards.—The composition of the concentrated food given to two-year-old bullocks receiving up to ¾ cwt. roots per head per day along with fodder crops, should conform to the following standards; although with a more liberal allowance of roots, the percentage of fibre in concentrates may be increased by one-half, provided the concentrates approximate to the higher percentage in albuminoids:—

(a) *Early stages of Fattening.*—Albuminoids, 15 to 20 per cent.; oil, 4 to 6 per cent.; fibre, not exceeding 15 per cent.

(b) *Later stages of Fattening.*—Albuminoids, 20 to 25 per cent.; oil, 6 to 8 per cent.; fibre, not exceeding 10 per cent.

Rations supplying a higher percentage of albuminoids than above are apt to be expensive, and in some cases disappointing in the results; *e.g.*, Dr Paterson (Glasgow and West of Scotland Agricultural College) had one lot of cattle fed with decorticated cotton cake alone, with a composition of $A_{48\%}O_{10\frac{1}{2}\%}F_{6\%}$, and a second lot fed with decorticated cotton cake and maize meal, the mixture giving a composition of $A_{26\cdot8\%}O_{7\cdot42\%}F_{4\cdot18\%}$. The latter ration gave a larger increase in live weight by

one-twelfth, and cost one-seventh less than was the case with the former.

It is well known that immature roots in the autumn tend to scour bullocks if fed in large quantities without suitable concentrates. Bombay cotton cake is known to have a very "binding" effect, and on this account has a special value. Mr Bruce, Edinburgh and East of Scotland Agricultural College, demonstrated this point very effectively in the bullock-feeding experiment of 1904-5.

One lot of cattle received 1 to 1¼ cwts. roots per head per day, with straw, and in addition 8 to 10 lbs. of concentrated food. The increase in live weight during the first three months was as follows:—

	Concentrated Food.	Aver. Monthly Increase in Live Weight.
1st month	8 lbs. Bombay cotton cake	70·7 lbs.
2nd "	8 " Bombay cotton cake	12·6 "
3rd "	8 " Bombay cotton cake 2 " linseed cake	97·7 "

The splendid return during the first month was no doubt due to the roots being immature, and the Bombay cotton cake counteracting the laxative effect of the roots; but during the second month the roots had ripened and had not such a laxative effect, hence the Bombay cotton cake was too binding. The addition of a laxative food like linseed cake to the ration improved matters considerably, and accounts for the enormous increase during the third month. The concentrated part of ration in the third month is very high in fibre (19·6 per cent.), and would, no doubt, have given much worse results if the roots had not been fed so liberally.

There does not appear to be any advantage in

using highly concentrated foods during the whole of the fattening period, for in Mr Bruce's report (1903-4) the bullocks receiving "decorticated" cotton cake cost 3s. more per cwt. of live weight increase to produce than was the case with those receiving Bombay cotton cake at first. In each case the ration was partly substituted later on with linseed cake. Further, the bullocks fed on the very rich concentrates (decorticated cotton cake and linseed cake) gave an increase of 62 lbs. live weight on the average per head during the last two months of fattening; while those receiving Bombay cotton cake with some linseed cake later on, gave 110 lbs. live weight increase in the same time, thus illustrating the principle that the concentrated part of the ration should gradually improve in quality as the fattening period advances.

The Edinburgh College experiments (Mr Bruce's reports, 1906) also shed light on the effect of feeding moderate as well as liberal amounts of concentrated foods. *E.g.*, when the bullocks were given an average daily allowance of 90 lbs. roots, with straw *ad lib.*, the average daily gain in live weight with those receiving on an average 6 lbs. Bombay cotton cake per day, was 1·78 lbs.; while with those bullocks getting 8 lbs. Bombay cotton cake per day, the daily increase in live weight averaged 2·02 lbs. per head per day. The bullocks receiving the heavier ration of cake (8 lbs. per day) were fat a fortnight earlier than those receiving the moderate ration (6 lbs. per day). The final returns for feeding were approximately the same in each case but, with the heavier feeding, the returns had to be accepted largely in the form of manurial residue, while with the lighter feeding (6 lbs. per day) there was a larger cash return.

Professor Winter of Bangor fed equal quantities of maize meal and decorticated cotton cake to both Welsh and Shorthorn bullocks, along with pulped swedes, hay and straw chaff *ad lib.*, and 5 lbs. hay each night. The results show that two-year-old bullocks receiving 6 lbs. of concentrates per day gave an average daily increase in live weight of 1·92 lbs., while those getting 10 lbs. concentrates per day only gave an average increase of 1·65 lbs. per day.

It is interesting to note the results of a concentrated ration which is high in fibre. Professor Brynner Jones carried out an experiment (1907-8, Aberystwyth) with the fattening of bullocks. The bulky part of ration consisted of straw chop, hay, and roots, while the concentrates were one part Bombay cotton cake, one part Egyptian and two parts barley meal, giving a composition of $A_{15\frac{1}{2}}O_{8\frac{1}{4}}F_{18}$. One lot received 6 lbs. per head per day of concentrates, and the other had 10 lbs. per day. The average daily increase in the former case was 1·37 lbs. per head, and in the latter 1·32 lbs. per head.

The heavy feeding of concentrates proved to be a dead loss, and the moderate feeding was not very satisfactory, due partly to the concentrated mixture being suitable only for the early stages of fattening, and at the same time rather low in oil.

This difficulty can be overcome to a large extent by making the ration sufficiently laxative; *e.g.*, in the 1911-12 experiments of the Edinburgh College, Mr Bruce's report shows that when Bombay cotton cake (4 lbs. per head per day) was fed along with the same weight of linseed cake, or $4\frac{3}{4}$ lbs. wheat bran per head per day, in addition to 90 lbs. swedes and 12 lbs. oat

straw, satisfactory results were obtained in both cases. The "linseed-cake mixture" of concentrates gave a composition of $A_{24}O_{7\frac{1}{4}}F_{15}$, and an average increase in live weight of 2·27 lbs. per head per day; while the "bran mixture" had a composition of $A_{17}O_{4}F_{15}$, and yielded an average increase of 2·02 lbs. per head per day.

The "bran mixture" actually left more profit, but the great point to remember when using concentrates high in fibre for fattening animals, is that the ration should be made more laxative in one or more of the following ways:—

(*a*) Substituting hay for straw (more especially in England).
(*b*) Increasing the allowance of roots.
(*c*) Including concentrates which have a laxative tendency.

The success of both the above rations was due in one case to including linseed cake, and in the other bran, both of which have laxative properties. Anyhow, cocoa-nut cake and Bombay cotton cake were fed in the same experiment, and the mixture gave a composition of $A_{20}O_{7\frac{1}{4}}F_{16\frac{3}{4}}$; but the daily live weight increase obtained was not so high (1·91 lbs.), very probably due to the mixture being richer in fibre and of a slightly more "binding nature."

The general rule in fattening cattle is that the allowance of concentrated food per day increases as fattening advances, but the average increase in live weight per day gradually diminishes as fattening advances. The latter point is very well seen if we take the Edinburgh Agricultural College experiments

during 1904-5 and 1906. The average increases in live weight per month during fattening of forty-eight bullocks were as follows:—

First month . .	74·33 lbs.
Second „	63·81 „
Third „	54·05 „
Fourth „	40·00 „
Fifth „ . .	43·87 „

Although not quite mathematical, the general tendency is apparent, and shows that the cost of producing increase in later stages of fattening is much greater than in the early period.

XXXI RATIONS FOR FATTENING CATTLE

The following daily rations are for bullocks of approximately 800 lbs. live weight (two-year-old), which are receiving oat straw or hay along with, say, ½ cwt roots per day. The amount of cake allowed is at the rate of 1 lb concentrated food for every 100 lbs live weight. Rations 1, 2, and 3 are not high in fibre, and would go well with straw, while 4 and 5 are fairly high in fibre and may be fed with hay. Ration 10 should also be fed with hay, and the remainder would do quite well with either oat straw or hay.

In making up bulk quantities, the constituent foods in the ration should be taken in the same proportions as those given, *e.g.*, in ration 1, if equal weights of each constituent were taken—whether pounds, hundredweights, or tons—the composition of the mixture[1] would remain the same.

[1] Farmers wishing to make up similar concentrated mixtures should refer to the table of analyses on p. 206.

Early periods of Fattening.

1. 2 lbs. bean meal or gram.
   2 lbs. dried grains (brewers').
   2 lbs. crushed oats.
   2 lbs. sharps.
   A[illegible] O[illegible] F[illegible]

2. 2 lbs. linseed cake.
   2 lbs. Bombay cotton cake.
   2 lbs. bran (wheat).
   2 lbs. maize meal.
   A[illegible] O[illegible] F[illegible]

3. 1 lb. decorticated cotton cake.
   2 lbs. Egyptian cotton cake.
   2 lbs. barley meal.
   2 lbs. rice meal.
   1 lb. locust bean meal.
   A[illegible] O[illegible] F[illegible]

4. 4 lbs. Egyptian cotton cake.
   3 lbs. crushed oats.
   1 lb. locust beans (kibbled).
   A[illegible] O[illegible] F[illegible]

5. 2 lbs. Egyptian cotton cake.
   2 lbs. dried grains.
   3 lbs. sharps.
   1 lb. locust beans.
   A[illegible] O[illegible] F[illegible]

Later stages of Fattening.

6. 3 lbs. decorticated cotton cake.
   5 lbs. maize meal.
   A[illegible] O[illegible] F[illegible]

7. 2 lbs. linseed cake.
   2 lbs. bean meal or gram.
   2 lbs. wheat bran.
   2 lbs. rice meal.
   A[illegible] O[illegible] F[illegible]

8. 2 lbs. decorticated cotton cake.
   2 lbs. linseed cake.
   1 lb. bean meal or gram.
   2 lbs. maize meal.
   2 lbs. rice meal.
   1 lb. bran.
   2 lbs. locust beans.
   A[illegible] O[illegible] F[illegible]

9. 2 lbs. earth nut cake.
   2 lbs. Egyptian cotton cake.
   5 lbs. maize meal.
   2 lbs. locust beans.
   A[illegible] O[illegible] F[illegible]

10. 2 lbs. soya bean cake.
    2 lbs. dried grains.
    2 lbs. rice meal.
    2 lbs. ground oats.
    A[illegible] O[illegible] F[illegible]

Condiments may be added in small quantity to any ration that the stock do not eat with avidity.

Comparison with Kellner Standard. The Kellner standard for full-grown fattening bullocks per 1000 lbs. live weight is as follows:—1·5 to 1·7 lbs. digestible albuminoids, and 12·5 to 14·5 lbs. starch equivalent.

If one takes a 1000 lbs. bullock which is receiving 21 lbs. oat straw and 84 lbs. swedes per day, together with one or other of the rations given on p. 253, it will be quite easy to ascertain the value of the ration according to the Kellner standard. Take, for example, rations 1, 2, 6, and 7. The Kellner values will be as follows:—

Ration.	Digestible Albuminoids.	Starch Equivalent.
1	[illegible] lbs.	[illegible] lbs.
2	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]

With the exception of ration 1, the albuminoids in each case are sufficient; while the starch equivalent is rather more than required in 6 and 7.

A useful deduction from Kellner's standards is that a full-grown bullock requires per 1 lb. increase in live weight, approximately 0.45 lb. digestible albuminoids and 3·75 lbs. starch equivalent.

Economy in Feeding

(a) It is wise economy to give a bunch of bullocks in autumn a small allowance of cake (2 lbs. per day each). Some of the bullocks will soon show a tendency to fatten, and these should then be drawn out and given a fattening ration.

(b) The bullocks should not be given more each time than they are able to clean up reasonably soon.

(c) The ration should not be too "binding," or too laxative, otherwise the increases in live weight obtained may be far from satisfactory.

(d) The bullocks should all have their teeth seen to at the beginning of the fattening period: chewing or mastication is well-nigh impossible in some cases until the offending tooth is removed.

(e) The times of feeding should be arranged so as to give bullocks plenty of time in the morning and afternoon to chew their cud in quietness. Continual disturbance of bullocks does not tend to encourage rapid fattening.

(f) Where the concentrated food comes up to the above feeding standard (p. 244), and is sufficiently palatable and laxative, experiments do not appear to show any great advantage of one mixture of concentrates over another; hence the market value of concentrated foods should be very carefully watched, so as to secure a ration of high quality and of the desired composition at the minimum cost (p. 158).

(g) Cattle feeding is an art as well as a science, and some cattle feeders are able to fatten cattle with much less concentrated food than others.

Relation of Concentrated Food consumed to Beef produced

With an average daily ration for a two-year-old bullock of 8 lbs. cake, 17 lbs. straw, and ½ cwt. roots per day, the average increase in live weight should be about ½ cwt. per month, or 2 lbs. per day. In Mr Bruce's

report (1906) the average increase per month was 56·6 lbs. per bullock.

At this rate :—

4½ cwts. cake give 1 cwt. increase in live weight.
100 lbs. „ „ 14 lbs. beef (60 per cent. carcass).
57 lbs. „ „ 8 lbs. „ „ „

Every ½ cwt. of cake fed to fattening bullocks should therefore give approximately a Smithfield stone of beef (8 lbs.)

Cost of producing Increase in fattening Bullocks.

With liberal feeding for two-year-old bullocks of 8 lbs. cake per head per day along with straw and roots, the cost of producing increase would be approximately as follows :—

Costs £2, 5s. to £2, 15s. in cake, straw, and roots, to give 1 cwt. live weight increase.

Costs about £2 in cake, straw, and roots, to give 1 cwt. live weight increase when manurial residue is taken into account.

Costs about £1, 10s. in cake, etc., to give 1 cwt. live weight increase when both manurial residue and enhancement in value of store weight of animal (say, 5s. per live cwt.), is taken into account, which must be credited to the food.

Bullocks should increase in value from £1, 5s. to £1, 10s. per month, if they are to leave a profit.

The returns per acre (20 tons) of roots with bullock feeding comes to about £8, without taking into account "manurial residue." With manurial residue accounted for, the returns would be about £10, 10s.

PLATE XXXIV.

Weight of Fat Cattle by Measurement.

It is not always possible to place an animal on the scales, consequently one has to resort to other methods of determining the live weight. A fairly easy method is to take the average girth in feet, and the length of the animal from a point just behind the shoulder to the root of the tail, also measured in feet; then by squaring the girth, and multiplying this number by the length in feet, a quarter of the result so obtained will then give the weight of the animal in imperial stones. *E.g.*, an animal with 6-foot girth, and body 6½ long, would be—

Girth squared × length ÷ 4 =	weight in imperial stones.		
$6 \times 6 \times 6\frac{1}{2} \div 4$	"	"	
$36 \times 6\frac{1}{2} \div 4 =$	"	"	
$234 \div 4 =$	$58\frac{1}{2}$ imperial stones.		

The above would be approximate for a very fat animal. If it is only moderately fat, at least one-twentieth would have to be subtracted from the result, and the amount deducted must be left to the judgment of the person estimating the weight of the animal.

Score-carding Cattle.

The score card on p. 258 is used by the students in the Winter School of Agriculture carried on by the Herefordshire County Council.

Hereford Bull.

	Max. Points
General Appearance, 26 points —	
CARRIAGE of animal when walking	3
SIZE AND WEIGHT, according to age	5
COLOUR AND MARKINGS	4
HAIR AND SKIN.—Skin thick and mellow to the touch, with thick soft hair	5
FLESH—Body well covered with flesh, which is firm and mellow to the touch, and free from patchiness	9
Head and Neck, 10 points —	
MASCULINE HEAD, horns slightly drooping, short face, prominent eyes, and flesh-coloured nose	6
NECK—Good crest, clean throat, the whole sloping gradually on to shoulders	4
Fore Quarters, 8 points —	
SHOULDERS not prominent, shoulder-blades well open on top, and well covered with flesh	8
Body, 24 points —	
CHEST wide and deep, well filled in behind shoulders, large heart girth	8
RIBS long, and well arched	4
BACK AND LOIN strong and broad, level with top line	8
FLANK—Full and well down, straight underline	4
Hind Quarters, 27 points —	
HIND QUARTERS as long and as wide as possible, well filled in from hip-bones to root of tail. Hip-bones not prominent. Tail well set on	16
UPPER THIGH full and well developed	5
LOWER THIGH prominent, and well fleshed down to hock	6
Legs, 5 points —	
LEGS—Should be short, set on well apart, strong clean bone	5
	100

The Hereford Herd Book Society has drawn up the following standard of merit for Hereford Cattle:—

Hereford Cattle.

The **Bull** should have a moderately short head; broad fore head. Horns waxlike, springing straight out from side of forehead and slightly drooping; those with black tips or turning upwards are not favoured.

PLATE XXXV

Eyes should be full and prominent.

Nose broad and clear. A black or blue nose is objectionable.

Body should be massive and cylindrical on short legs. The upper- and underline should be straight. The neck should be thick, with well-developed crest.

Shoulders sloping, but lying well open at top between blades.

Chest full and deep. Ribs well sprung. Flank deep.

Buttocks broad, with lower thigh well developed, coming well down to hocks.

Tail neatly set and evenly filled between setting-on of tail and hip-bones (hooks). The hip-bones should not be prominent.

Whole carcass should be covered with firm flesh.

Skin should be thick and mellow to the touch, and generally covered with thick soft hair of a rich red colour. The hair, however, of face, top of neck, and under parts of body should be white.

Hereford Cow should be more feminine in appearance. Head and neck less massive, and the eyes should show a quiet, docile disposition.

XXXII. LIVE WEIGHTS OF CATTLE OBTAINABLE BY INTENSIVE FEEDING.

The tables on pp 260-267 have been calculated from the Smithfield results of 1913, and have been specially arranged to show the possible live weights attainable by various breeds at different ages. The table includes the daily increase in live weight from birth of the three prize-winners in each class where available, as well as the average daily increase from birth of the whole class.

The table on p. 267 gives the live and carcass weights of those cattle entered in the carcass competitions as well as the percentage of carcass to live weight, weights of internal organs, etc., and comparative prices per 8-lb. stone of the various carcasses.

Smithfield Show, 1913—Cattle.

Breed Competitions, showing Live Weight attained by Prize Winners, and Daily Increases from Birth.

Competitors No. in Class	BREED	[illegible]	Age		Live Weight			Daily Gain		[illegible]	Daily Gain of all Animals in Class	
			wks.	days	cwts.	qrs.	lbs.	lbs.	ozs.		lbs.	ozs.
	(a) Steer not exceeding Two Years of Age—											
51	Shorthorn steer	1	102	2	14	0	9	2	1·19	11	2	2·85
45	"	2	103	4	13	3	19	2	2·36			
57	"	3	101	3	14	2	20	2	4·96			
27	Hereford steer	1	96	2	13	1	19	2	3·62	10	2	2·08
25	"	2	93	0	13	3	14	2	4·45			
20	"	3	97	5	13	1	26	2	3·27			
316	Shorthorn × Aberdeen-Angus	1	96	0	12	2	0	2	1·13	11	2	1·04
315	" " "	2	97	4	13	1	18	2	1·13			
321	Aberdeen-Angus × Devon	3	97	1	12	1	11	2	0·54			
76	Sussex steer	1	102	2	13	0	22	2	0·98	12	2	0·27
75	"	2	100	0	13	1	8	2	2·55			
85		3	98	4	13	0	26	2	2·31			

171	Welsh steer	1	103	2	14	3	19	2	4·91	7	2	5·14
170	,,	2	103	6	12	1	15	1	14·48			
176	,,	3	99	2	12	2	4	2	0·08			
121	Aberdeen-Angus steer	1	103	3	14	2	23	2	2·00	7	1	15·57
123	,, ,,	2	87	2	12	0	8	2	3·12			
120	,, ,,	3	101	4	11	2	24	1	13·34			
152	Shorthorn × Aberdeen-Angus—Shorthorn	1	[illegible]	2	13	1	6	2	2·26	8	1	15·45
151	Aberdeen-Angus × Shorthorn—Shorthorn-Aberdeen-Angus	2	101	5	15	0	5	2	4·88			
153	Shorthorn × Aberdeen-Angus—Shorthorn	3	102	3	12	2	16	1	15·55			
113	Red Poll steer	1	100	1	11	0	10	1	12·30	4	1	14·59
111	,,	2	102	0	12	2	14	1	11·64			
112	,,	3	96	4	11	0	22	1	13·63			
159	Galloway steer	1	98	5	11	0	24	1	11·04	3	1	15·13
160	,,	2	97	0	11	0	2	1	13·03			
[illegible]	Devon steer	1	[illegible]	3	10	2	20	1	12·35	5	1	13·09
4	,,	2	97	2	10	0	6	1	11·27			
2	,,	3	104	0	11	3	14	1	13·15			
[illegible]	Aberdeen-Angus × Dexter	1	92	[illegible]	8	2	16	1	6·77	6	1	6·62
294	,, ,,	2	102	4	8	2	23	1	5·91			
295	,, ,,	3	101	5	8	0	[illegible]	1	4·10			
285	Dexter-Kerry steer	1	82	5	6	2	26	1	4·72	3	1	3·44
286	,, ,,	2	112	0	7	1	14	1	3·73			
287	,, ,,	3	81	2	5	2	18	1	1·75			

Smithfield Show, 1913—Cattle. Breed Competitions—*continued.*

Competitors' No. in Class	Breed	Prize awarded	Age		Live Weight			Daily Gain		Animals in Class	Daily Gain of all Animals in Class	
	(b) Steer not exceeding Three Years of Age—		wks.	days	cwts.	qrs.	lbs.	lbs.	ozs.		lbs.	ozs.
108	South Devon steer	1	147	1	17	3	2	1	14·79	3	1	15·72
110	,, ,,	2	139	4	18	1	22	2	1·73			
29	Hereford steer	1	151	6	18	3	16	1	15·79	3	1	14·03
30	,,	2	147	4	17	1	14	1	14·08			
31	,,	3	152	2	16	2	24	1	12·23			
63	Shorthorn steer	1	149	5	16	2	6	1	12·25	6	1	13·88
64	,,	2	142	6	17	2	24	1	15·64			
61	,,	3	149	2	16	3	14	1	12·88			
229	Shorthorn × Aberdeen-Angus	1	155	1	17	2	10	1	13·35	9	1	13·64
230	,, ,, ,,	2	128	5	15	3	7	1	15·74			
226	Aberdeen-Angus × Shorthorn	3	147	2	17	1	11	1	14·09			
6	Devon steer	1	151	6	16	3	18	1	12·55	7	1	12·56
7	,,	2	134	5	14	3	3	1	11·55			
10		3	155	3	15	3	6	1	9·98			
90	Sussex steer	1	135	0	16	3	26	2	0·74	10	1	12·22
95	,,	2	151	3	17	0	8	1	12·86			
87	,,	3	142	4	16	2	13	1	13·74			
163	Galloway steer	1	147	2	16	0	0	1	11·75	5	1	11·98
164	,,	2	150	1	15	0	9	1	11·36			

130	Aberdeen-Angus steer	1	145	2	16	0	0	1	12·08	17	1	11·71
127	"	2	110	5	17	3	21	1	14·35			
142	"	3	148	4	15	3	4	1	11·09			
181	Welsh steer	1	133	2	17	1	17	1	13·39	12	1	10·42
185	"	2	142	1	18	[illegible]	10	1	14·78			
183	"	3	141	5	15	0	14	1	11·24			
262	Aberdeen-Angus [illegible]	1	136	5	13	3	4	1	12·83	12	1	10·33
264	Aberdeen-Angus × Aberdeen-Angus [illegible]	2	14[illegible]	1	16	1	22	1	11·92			
265	Aberdeen-Angus × Aberdeen-Angus Ayrshire	3	149	–	17	2	16	1	14·04			
116	Red Poll steer	1	135	5	11	1	8	1	9·02	1	1	9·02
197	Highland steer	1	148	2	14	1	2	1	9·82	7	2	8·12
193	"	2	144	4	11	2	8	1	8·12			
198	"	3	15[illegible]	1	11	1	26	1	7·79			
300	Aberdeen-Angus [illegible]	1	148	2	12	–	21	1	[illegible]	3	1	7·64
301	"	2	131	2	11	1	12	1	5·76			
302	"	3	136	4	10	2	–	1	3·62			
258	Dexter Kerry	1	148	6	8	1	2	0	13·03	3	0	14·34
256	"	2	144	4	8	–	1	0	14·26			
257	"	3	114	2	8	6	6	–	15·18			
	(c) Heifer not exceeding Two Years of Age											
273	Shorthorn × Blue-grey [illegible]	1	96	1	11	3	14	1	15·45	7	2	8·75
279	Aberdeen-Angus × Shorthorn, Hereford Shorthorn	2	81	4	12	0	21	2	6·17			
271	Aberdeen-Angus × Shorthorn × Aberdeen-Angus	3	101	6	13	1	10	1	11·24			
13	Devon heifer	1	97	6	12	2	3	2	0·60	2	2	3·33
14	"	2	93	4	11	2	12	1	15·45			

Smithfield Show, 1918—Cattle. Breed Competitions—*continued.*

Competitors' No. in Class.	BREED.	Prize awarded	Age		Live Weight			Daily Gain		Animals in Class.	Daily Gain of all Animals in Class	
			wks	days	cwts	qrs	lbs	lbs	ozs		lbs	ozs
	(c) Heifer not exceeding Two Years of Age—*continued*											
33	Hereford heifer	1	102	1	13	0	20	2	0·98	6	1	13·74
34	"	2	97	5	12	0	0	1	15·39			
37	"	3	101	5	10	3	20	1	10·93			
148	Aberdeen-Angus	1	99	5	11	3	26	2	1·70	6	1	13·71
145	"	2	98	1	11	3	25	1	15·06			
146	"	3	100	[illegible]	11	1	22	1	13·26			
68	Shorthorn heifer	1	93	2	13	0	24	2	4·09	5	1	15·64
69	"	2	99	3	11	0	10	1	12·54			
71	"	3	98	5	11	2	20	1	14·24			
97	Sussex heifer	1	99	0	13	0	14	2	1·89	6	1	15·58
99	"	2	99	3	12	1	5	1	13·38			
102	"	3	95	4	11	2	14	1	15·08			
236	Shorthorn × Aberdeen-Angus	1	100	3	11	3	21	1	14·38	9	1	14·44
239	" "	2	94	2	11	1	4	1	14·50			
237	Aberdeen-Angus × Shorthorn	3	93	0	11	0	26	1	14·77			
	(d) Heifer not exceeding Three Years of Age—											
249	Shorthorn × Aberdeen-Angus	1	146	2	15	2	16	1	11·27	4	1	10·47
248	"	2	151	0	14	3	18	1	9·35			

72	Shorthorn heifer	1	153	6	14	0	22	1	7·57	3	1	10·14
74	"	2	114	1	13	1	22	1	13·68			
73	"	3	147	1	15	2	72	1	10·84			
16	Devon heifer	1	140	6	14	0	10	1	9·58	3	1	10·03
18	"	2	144	6	14	1	2	1	9·49			
17	"	3	133	6	13	3	23	1	10·60			
103	Sussex heifer	1	150	3	14	3	0	1	9·05	5	1	9·70
104	"	2	149	0	16	1	20	1	13·01			
107	"	3	143	3	14	0	3	1	8·93			
281	Aberdeen-Angus × Aberdeen-Angus—Shorthorn—Aberdeen-Angus	1	144	4	13	2	26	1	11·74	5	1	9·63
282	Aberdeen-Angus × Aberdeen-Angus—Shorthorn	2	135	3	14	0	16	1	9·58			
283	Aberdeen-Angus × Aberdeen-Angus—Shorthorn—Ayrshire	3	154	6	14	3	16	1	8·57			
115	Red Poll heifer	1	159	1	11	0	25	1	13·23	3	1	9·60
117	" "	2	143	6	11	1	14	1	7·86			
119	" "	3	143	6	14	0	6	1	9·05			
189	Welsh heifer	1	143	0	13	0	5	1	10·53	3	1	9·52
190	"	2	133	1	13	0	4	1	11·07			
192	"	3	150	0	13	2	2	1	7·02			
157	Aberdeen-Angus heifer	1	143	[illegible]	15	1	20	1	12·40	7	1	8·93
153	" "	2	154	4	14	0	26	1	7·42			
156	" "	3	148	4	11	1	16	1	7·03			
40	Hereford heifer	1	151	1	13	2	22	1	7·18	3	1	7·84
41	"	2	141	5	13	3	22	1	9·11			
42	"	3	153	6	14	0	4	1	7·31			

Smithfield Show, 1913—Cattle. Breed Competitions—*continued.*

Competitors' No. in Class	BREED	Prize awarded	Age		Live Weight			Daily Gain.		Animals in Class	Daily Gain of all Animals in Class.	
			wks	days	cwts	qrs	lbs	lbs	ozs		lbs	ozs
	(d) Heifer not exceeding Three Years of Age—*continued*											
167	Galloway heifer	1	154	0	12	1	12	1	4·64	3	1	4·??
168	,,	2	141	0	12	3	2	1	7·11			
302	Aberdeen-Angus × Dexter	1	146	0	10	2	27	1	2·76	5	1	1·58
303	,,	2	?6	1	8	0	18	1	5·76			
304	,,	3	155	4	8	0	14	0	15·37			
291	Dexter Kerry	1	123	1	9	2	2	1	3·71	3	1	0·10
292	,,	2	131	5	7	3	12	0	15·22			
293	,,	3	14?	0	8	0	22	0	14·95			
	(e) Heifer not exceeding Four Years of Age—											
310	Highland heifer	1	201	2	13	0	16	1	0·47	7	1	0·86
311	,,	2	193	4	12	0	24	1	0·07			
312	,,	3	195	4	13	1	20	1	1·53			

Smithfield Show, 1913—Cattle. Carcass Contests.

BREED	Age		Live Weight	Carcase Weight	Percentage of Carcase Weight to Live Weight	[illegible], Caul, Rand Fat	Fat, Gut, Fat Trimmings	Tongue, Tail	Head, Feet	Heart, Liver, Lights	Tripe, Paunch, and Blood	Hide	Intestines	Carcase Award	Price per Stone (8 lbs.)	
Steer not exceeding 2 Years—	wks.	dys.	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		s.	d.
Shorthorn Angus	88	2	1217	814	66·8	17	24	10	31	35	92	75	18	1st & r. ch.	6	2
Aberdeen-Angus	87	3	1120	745	66·5	17	19	8	48	32	79	75	12	2nd	5	8
Angus Shorthorn	86	5	1274	835	65·5	13	25	1[illegible]	51	36	103	86	14	3rd	5	6
Shorthorn	82	2	1303	818	62·7	17	19	1[illegible]	53	37	133	84	16	4th	4	8
Devon	95	0	926	584	63·3	7	15	8	37	26	57	69	15	r. & h.c.	6	6
Blue-Grey	91	0	1298	852	65·6	14	19	11	[illegible]	38	108	84	15	...		
Galloway	93	5	1045	668	63·9	13	20	9	46	30	87	85	12	...		
Steer above Two and not exceeding Three Years Old—																
Galloway	130	[illegible]	1356	913	67·[illegible]	21	28	11	[illegible]	32	101	90	17	1st	5	0
Shorthorn Highland	136	1	1234	857	69·[illegible]	19	27	11	55	32	93	110	14	2nd	5	2
Shorthorn-Angus	154	3	1378	916	66·4	18	28	1[illegible]	55	41	99	84	17	3rd	4	0
Aberdeen-Angus	144	3	1498	1066	71·8	22	29	12	55	42	68	95	16	4th	4	4
Angus Shorthorn	149	6	1429	808	56·5	25	41	13	33	35	118	86	16	r.	4	6
Angus Shorthorn	125	5	1244	813	65·2	17	22	9	52	32	111	81	14	...		
Heifer not exceeding Three Years Old—																
Aberdeen-Angus	98	5	1125	740	65·7	19	22	9	42	32	86	76	15	1st & ch.	7	0
Galloway	99	3	1188	760	64·4	21	32	12	65	31	86	73	17	2nd	5	2
Aberdeen-Angus	100	1	1190	797	66·9	16	18	12	45	33	134	79	15	3rd	5	0
Aberdeen-Angus	100	5	1220	798	65·4	19	25	10	44	29	124	71	14	4th	4	4
Shorthorn Angus	99	5	1272	821	64·5	23	35	10	45	35	107	75	20	r. & h.c.	5	4

8 cwts. = 896 lbs.; 9 cwts. = 1008 lbs.; 10 cwts. = 1120 lbs.; 11 cwts. = 1232 lbs.; 12 cwts. = 1344 lbs.; and 13 cwts. = 1456 lbs.

XXXIII. FEEDING OF SHEEP

The provision of food for sheep is a matter of very great importance, but the kind of food required on different farms varies considerably. On the mountain and hill land the flocks may have to rely on grass almost entirely for their living except in very severe weather in winter, when they will, in all probability, be given a little hay. On such farms there is no attempt made to fatten sheep off, consequently they are disposed of, in store condition, to lowland farmers, who fatten them off at the age of two and a half to three years.

The breeding ewes are generally sold after they are five years old to lowland farmers, where they may be fattened off, or crossed with a good fattening breed of sheep. In the latter case, both ewes and lambs would be fattened off the following year.

The all-important point for these farmers is how to get an abundant supply of grass throughout the greater part of the year, either by improving the old grass-land, or, when land is laid down to grass, by seeding it down with a good pasture mixture (see p. 95). A good supply of hay should be preserved for the snowy weather in winter.

On some lowland farms where grass is abundant in autumn, these hill or mountain sheep may be purchased in late August or early September, and simply allowed to fatten themselves off on the pasture grass, foggage, or young grass and clover seeds, which give them a much more sappy and nutritive feed than that on which they have been reared. In about two to three months' time they will probably be sufficiently fat to sell, leaving 6d. to 9d. and, in

some cases, 1s per head per week for the grass consumed.

It is on the mixed lowland farms, where sheep are both bred and fattened, that one gets the widest experience with sheep, and it is on such farms that the following remarks are chiefly intended to apply. The class of sheep bred on lowland farms are much larger than the hill and mountain sheep, largely due to the fact that they have been bred and selected for the production of mutton at a much earlier age than is the case on hill farms.

Feeding the Ram.

Previous to being placed with the ewes, the ram should be specially fed for a few weeks so as to put him into proper condition. If too fat, he should have plenty of exercise and shorter rations. The concentrated food should be fairly rich in albuminoids, and may well consist of equal parts of bran and oats, allowing about 1 lb per head per day. Many of the best breeders give each ram a couple of doses of Epsom salts before placing him with the ewes. The time of year when the ram would be placed with the ewes would depend on the breed as well as the purpose for which the lambs were required; *e.g.*, Dorset breeders place the rams with the ewes from beginning of September to middle of October. The same applies to other districts where early lambs are fattened off; while in hill districts, where the lambs are reared and sold out later on in store condition, it is not usual to have the lambs coming before April.

Breeding

It is a very good thing to "flush" the ewes for a few weeks before they are put with the ram. This simply means allowing the ewes to have a little better feeding so as to improve their condition, but not sufficient to make them fat. This has the dual effect of getting the ewes mated a little earlier and of increasing the number of twins or doubles.

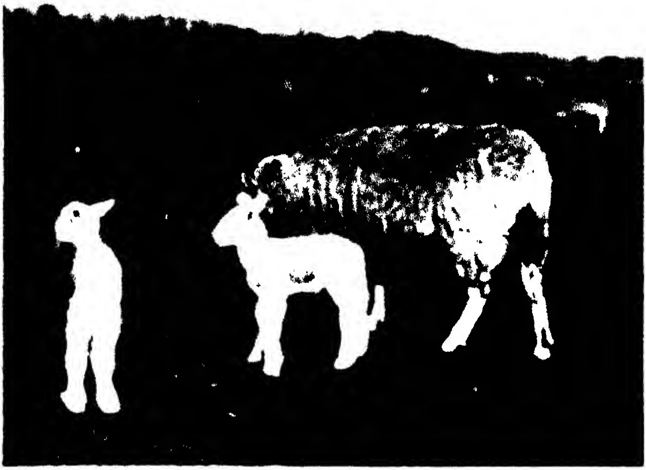
During pregnancy the ewes should be fairly liberally fed by hand if grass is not sufficiently plentiful, so as to keep them in a thriving condition. A moderate allowance of roots may be given (11 lbs. per head per day, or, say, a cart-load to 100), but frozen roots should always be fed with caution. A little cake (¼ lb. per head per day) may also be found necessary. The ewe will then be in fairly good condition at lambing time, produce stronger lambs, and nurse them better.

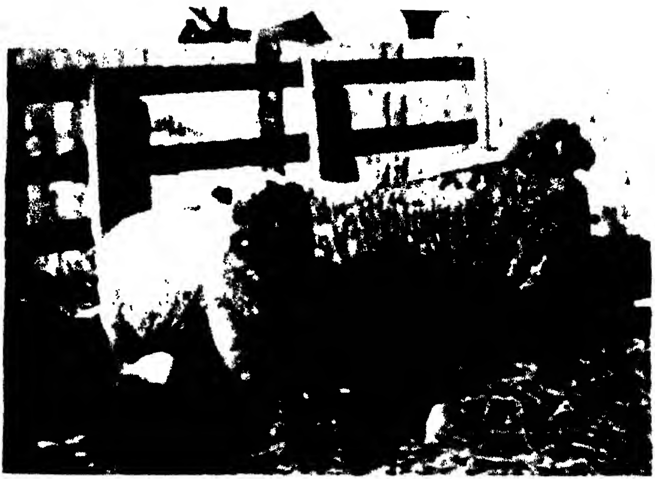
At lambing time a sufficient supply of hay, straw, and roots near the lambing pen is very necessary. The ewes will be taken into it for a day or two before lambing, more especially at night. After lambing, hay and 1 to 2 lbs. of concentrated food, made up of the same ingredients and in the same proportions as those for dairy cows (see p. 211), should be given, along with some nice, succulent roots (14 to 21 lbs. per head per day) or grass.

Fattening Early Lambs

The fattening of lambs for the early market is becoming more and more popular, for several reasons: (*a*) the lambs yield quick returns; (*b*) the price, generally speaking, is comparatively high; (*c*) they are fattened off

PLATE XXVI.





before parasites become troublesome; and (d) they give the farmer an opportunity of relieving the pastures in the summer months, especially when he can purchase sheep or lambs in the early autumn for feeding off the roots. This also means that the number of sheep kept on the farm during the year is increased, and the profit from them greater.

Hill sheep are comparatively slow fatteners, and possess a roaming disposition; but they are good milkers, make admirable mothers, and when fat, produce a sweet, fine-grained mutton which contains a high proportion of lean meat, hence they are mated with a larger breed to get the first cross ewes; then, in order to get lambs which will grow and fatten rapidly, it is necessary to cross these ewes with rams of some of the larger breeds which are noted for their mutton-producing capacities, such as the Oxford, Hampshire, etc. It is further important that these cross-bred lambs should have an aptitude to both grow and fatten during the first few months of their lives. Principal Lawrence found in his experiments that while the lambs produced by the Oxford ram crossed with Border Leicester Scotch Black-faced ewes could be fattened off in three months, it took an extra month to fatten the lambs produced when a Wensleydale ram was used with similarly bred ewes. The Oxford Down and Hampshire Down are certainly very popular for crossing with the local ewes, although Border Leicesters and Suffolks have given very good results. With fairly large ewes like Romney Marsh or Kent sheep, the South Down makes a very fine cross.

In East Lothian the three-crop ewes are sometimes weaned from their lambs towards the end of July, so as to get them lambing early (January or early February)

with the fourth crop of lambs. The ewes and their lambs are then fattened off together. Some of the single lambs will be sufficiently fat in about ten weeks, and probably weigh 56 to 60 lbs. live weight, and if of good quality will command a high price; in fact, those which are sold later and at probably a month older, may not make such a high price per head.

The ewes are given a liberal amount of concentrated food (1 to 2 lbs.), made up in the same proportions as the rations for dairy cows (see p. 211), along with hay and up to 20 lbs. roots. In about three weeks the lambs will begin to eat cake, etc., out of the troughs. This is encouraged, and the lambs are fattened as rapidly as possible. At the same time the "top" lambs will be placed on the best grass or young wheat and given every advantage, so as to get them fat in time to catch the early market, say, from mid-April up to the end of May. A large number are sold off in June and early July, and may weigh anywhere from 60 up to 100 lbs.

Mr Wyllie, writing in the *Transactions of the Highland and Agricultural Society of Scotland for* 1907, mentions a novel way he has of giving the lambs the best of the cake. The ewes are fed with "rough" (undecorticated) coarsely broken cotton cake, and as soon as the lambs show an inclination to eat cake, linseed cake broken down to the size of beans is added; with the result that the lambs, being unable to deal with the larger pieces of cotton cake, feed chiefly on the linseed cake, while curiously enough, Mr Wyllie points out, the ewes seem to prefer the cotton cake after they have become so accustomed to it.

In some cases the lambs may receive special and

probably more expensive feed than the ewes by training them to eat in a little enclosure. A very useful lamb food for this purpose may be made by mixing—

2 parts linseed cake.
1 „ soya bean cake.
2 „ cracked maize.
2 „ crushed oats.
1 „ locust beans (kibbled).
Composition of mixture, $A_{14}O_{6}F_{6}$.

They may be allowed 1 lb of above mixture to every six or eight lambs at about a month old. At two months they will eat very nearly ¼ lb. each per day; at three months, ½ lb.; and if kept till four months old, may consume very nearly ¾ lb. per head per day.

It is a very common sight in East Lothian to see shelters put up at different parts of the field for the ewes and young lambs to shelter behind. These shelters are made of hurdles, with bunches of straw attached, and held in the vertical position. Although these shelters are not costly they are very effective, so far as the purpose for which they are intended is concerned.

The ewes would be sold off during June or July, and where they have been bought on, say, in the previous September, it is usual to expect that the selling price of ewes when sold will be approximately equal to the purchase price, the fleece being left over to go in part payment of the food consumed during the winter. If the ewes and lambs do well, one may realise a balance after making allowance for grass, roots, hay, and concentrated food, etc., of £1 to £2 for each ewe, including her lambs.

Wintering Lambs

On a large number of farms the ewes do not begin to lamb until April, when grass is beginning to grow. Very little if any concentrated food is given. About the end of August or beginning of September the lambs are weaned. With hill and mountain sheep, the lambs which are retained by the farmer are usually sent in the autumn to the lowland farms for the first winter, *i.e.* from 1st November to 1st April, when the owner will take turnips either per head of sheep (say, 5d to 6d per head per week), the owner supplying ½ lb. cake per head per day, or per acre of roots, depending on the size of the crop. *E.g.*, at West Linton, Peeblesshire, they are sometimes let at £6, 10s per acre; the farmer supplies the hay, and carts the cake for the owner. For wintering lambs the price is about £5 to £6 per score, or even more. These lambs would return to the hills and mountains the following spring, where they would remain over the second winter, and in the following autumn (two and a half years old) those which were not required for stock purposes would be sold at the great "store" sales to the arable farmers, and in some cases dairy farmers, to be fattened off for mutton during the late autumn, winter, or spring months as the case may be. Some of the lambs sent down from the hills and mountains to lowland farms may be fattened off during the first winter, say at nine months old, in the same way as those bred on the lowland farms.

Mutton Production

In the early part of the autumn, the hill and mountain sheep which pass through the auction marts in thousands supply the lowland farmer with store

sheep, which he can fatten off on his root-land. The particular name given to sheep which are being fattened off on roots with hay and cake varies in different parts of the kingdom; *e.g.*, in Scotland a very common term is "hoggets" for weaned lambs up to first shear, and "hoggs" after that. In the Midlands and south of England the term "teg" is often used instead of "hoggs." The chief difficulty about the term "hogg" is that one may very easily confuse it with another kind of farm animal spelt with one "g" instead of two.

These sheep would first of all be kept on the grass-land for a few weeks before being taken on to the turnip-land. The arable farmer who goes in for mutton production has reduced to a fine art the method of growing root or forage crops, so as to have a succession of succulent food for the sheep during the winter months. *E.g.*, with root crops, white-fleshed turnips generally come first. These are followed by the "yellows," or yellow-fleshed turnips, and are themselves succeeded by swedes. In the Midlands and south of England mangels may be fed to a larger extent than swedes. Mangels must be put into heaps or "tumps," and protected during the winter frosts, but it is more or less optional in the case of the turnips, yellows and swedes. Generally speaking, they are not carted off the land, although in some cases, say, six drills may be alternately carted off and six left; the idea being more to get the sheep to manure the field uniformly and well. In some cases the treading of the sheep would be an advantage, in others not.

The four common methods of feeding the roots off are—(*a*) open grazing; (*b*) folding, and eating the roots whole; (*c*) eating the roots whole through feeding-

hurdles; (*d*) folding the sheep, and feeding on cut roots.

Open Grazing.—The sheep are turned into a root-field, and allowed to roam at large. This saves netting or hurdles, but a large amount of food is wasted partly through the sheep having too much freedom, and partly through some of the roots becoming tainted. A further consideration on sandy soils, is that sand gets washed or carried by the feet of the sheep on to the roots, with the result that a considerable amount of sand may find its way into the stomachs of the sheep, and possibly cause death. With regard to the manure, this is not scattered uniformly over the field, which is a great disadvantage.

Folding Sheep.—In this method the sheep are confined by nets, wire-netting, or hurdles to a comparatively small area of roots, depending partly on the number being fed, length of nets, etc. In East Lothian about 50 yards by 50 yards is the area enclosed. The sheep are consequently confined to this area till the roots are practically all eaten up, before another break is given to them. The nets, etc., are kept fairly close up behind them, so as to keep the sheep from manuring one patch more than another. The advantages here are that the roots go very much further, and the field is uniformly manured. The sheep are more settled, and fatten faster. When a change is being made from turnips to swedes, the net or hurdle should be fixed so as to include a few rows of swedes, etc. In this way the sheep gradually become accustomed to the change.

In fine, dry weather it is often advisable to fold the sheep on the wettest and most exposed part of the field, and *vice versâ*. Changes to a fresh break should

PLATE XXXVIII.

generally be made in the late morning, or early afternoon, when the leaves or tops are comparatively dry, in order to prevent the food from scouring the sheep. Roughly speaking, an acre (20-ton crop) of swedes would keep about 300 sheep for a week, allowing 21 lbs. per head per day. An acre (15-ton crop) would keep 300 sheep for a week if only 16 lbs. roots were allowed per head per day.

Some farmers sow a little salt on the tops of the first break of turnips, to prevent the sheep from becoming "hoven" or "blown."

Feeding-hurdle System.—This is intended to apply to the system of using feeding-hurdles against the part which has to be fed off. It differs from the folding system, inasmuch as the hurdles are daily shifted forward against the roots. The sheep are not allowed to get their feet on or taint the roots, but may put their heads between the bars of these feeding-hurdles and eat the roots at leisure. This is a very economical way, although the expense of getting these hurdles is greater than that of the ordinary hurdles, and much more than that of getting nets or wire-netting. There is also more trouble in moving the hurdles forward each day.

This method is very conveniently applied in feeding off rape, vetches, and other forage crops.

Feeding Out Roots.—The roots, which have been topped, tailed, and put into small heaps or "tumps," are covered over with "tops," rough grass, straw, or soil, to protect them from the frost. These heaps are made of a convenient size, and placed at such a distance apart as to expedite feeding. The sheep would then be divided up into lots not exceeding 100 each, and drafted so as to have the forward ones together for

special feeding. It is usual to have a separate cutter (which cuts the roots into long chips or fingers) for every one or two lots of sheep, and as fast as one heap becomes used up, the hurdles are pushed forward against the next. At the same time the land gets uniformly manured.

The sheep are thus relieved of the trouble of breaking their own roots, and as soon as November comes in they may be handicapped by teething changes taking place. They can still get their full quantity of roots with a minimum amount of trouble, thus giving them longer periods of rest. It is not advisable to fill the troughs full of cut roots, say, morning and afternoon, because so many get pulled over the side of the trough and wasted. Further, in frosty weather any roots which are not cleaned up immediately, become frozen, and on this account are much less suitable for fattening purposes. It is much better to feed the cut roots three to four times a day, and give them no more than they can clean up immediately.

The feeding of cut roots for sheep which are being fattened off for mutton is very general, at any rate after the supply of soft turnips has become exhausted. The quantity allowed with hay and cake is anywhere from 14 to 21 lbs. per head per day, depending on the size of sheep, etc. Sheep have been fattened off on hay and roots, but the mortality is apt to be high, and the cost of producing live-weight increase considerably increased. Feeding the roots cut reduces the mortality, as the sheep get very little sand with their roots compared with the practice of feeding the roots off whole on the ground.

Principal Lawrence found that sheep receiving cake, hay, and *turnips* increased in live weight at the

PLATE XXXIX

average rate of 2¾ lbs. per head per week during a period of twelve weeks, while those receiving cake, hay, and *grass* only increased at the average rate of ¾ lb. per head per day.

In the same series of experiments it appears that the sheep being fed on *turnip-land*, with a given ration increased in live weight on an average during twelve weeks of 2¾ lbs. per head per day, while a similar lot, similarly fed on *grass-land*, only increased at the rate of 1¾ lbs. per head per day.

With cut swedes one penny per head per week may be charged for each hogg to cover cost of pulling and heaping swedes, and another ½d. per head per week for cleaning and cutting them for feeding.

One man can cut roots for, and look after a flock of 200 to 300 sheep. If, however, the roots are fed whole, he will manage to look after 400 sheep which are being folded on roots.

Forage and Fodder Crops for Sheep.

Forage Crops.—Forage crops are often used in the Midland counties and south of England to supply the succulent food for sheep. The chief crops used for this purpose would be lucerne, vetches, trifolium, rape, mustard, broadcast turnips, rye, oats, and vetches, etc. (see p. 99). Turnip tops and broadcast turnips are very useful remedies for lambs which are suffering from husk or hoose. Of course it is always advisable to treat lambs suffering from such complaints in the early stages.

Hay.—Hay is a bulky, and comparatively speaking a dry food, which is fairly high in fibre. This dryness and binding (fibrous) nature of hay makes it extremely

useful for feeding to "hoggs" which are receiving roots. The roots are cooling and laxative, and the hay tends to counteract the latter effect. It is very interesting to find that the hoggs regulate their diet instinctively. *E.g.*, in the 1904-5 experiments of the Edinburgh Agricultural College, where approximately 12½ lbs. roots per head per day were allowed to each lot, with hay *ad lib.*, it was found that those lots receiving "roots and hay alone," and "roots, hay, and linseed cake," both of which are fairly laxative rations, consumed approximately double the amount of hay of those receiving concentrates high in fibre (Bombay cotton cake or Bombay cotton cake and dried grains), with the same allowance of roots. This is an important practical point to keep in mind when compounding rations for sheep.

Oat straw may be used to economise the hay, but it is more usual to feed it chaffed and mixed with meals.

The allowance of hay per head per day varies from ½ lb. to 1½ lbs. A good average would be 1 lb., and in reserving hay for hoggs on roots, it is generally sufficient to allow 1 ton for every acre of roots to be fed off. If hay is scarce, it may all be chaffed and fed in troughs. The hay chaff and cake need not be mixed together at all, as the former can be fed in special troughs with backs on, and the latter in the usual kind of trough.

Concentrated Foods.

The primary object in feeding concentrates to sheep is to supply sufficient nutrient material to provide for an adequate surplus over what is required for mainten-

ance, and thus encourage rapid fattening. In the autumn, turnips fed before they are properly ripe tend to scour the sheep. This tendency can be largely counteracted by feeding liberal amounts of Bombay cotton cake as long as this tendency lasts; but as the turnips mature, or a change is made on to swedes, it will generally be found necessary to give concentrates of a more laxative tendency than Bombay cotton cake. If Egyptian is rather too binding, one cannot do better than include some linseed cake, which has a laxative tendency, and generally gives good results when given to fattening sheep.

Many of the rations for fattening cattle (see p. 253) would do very well for sheep, but it is important to keep in mind that sheep have their concentrated foods put into troughs in the dry state, and in the open field, where finely ground meals would generally be inadvisable, as the wind would blow much away. It is therefore best to feed maize, beans, oats, gram, soy beans, etc., cracked or coarsely bruised, so as to overcome this difficulty. Rations 2 and 4 would be very suitable for the first two months of fattening. A capital mixture could also be made by taking:—

1 part soya-bean cake.
2 parts Egyptian cotton cake.
2 ,, dried brewers' grains.
2 ,, cracked maize.
1 part locust beans (kibbled).

$A_{11}O_{6}F_{10}$

In the later stages of fattening, rations 6, 8, and 9 would give very good results, but the food should be fed in a much coarser condition than the

meal form. Another very good concentrated mixture for the later stages of fattening would be:—

2 parts linseed cake.
1 part Egyptian cotton cake.
1 „ crushed beans.
1 „ crushed oats.
3 parts cracked maize.
Little molassine or other condimental food.

$A_{20}O_{61}F_{8}$.

The amount of concentrated food to allow for sheep fattening on roots would be at the rate of about 1 lb. per 100 lbs. live weight. It takes three to four months to fatten average sheep off, and during this time they should give an increase in live weight of 2 to 3 lbs. per head per week.

In the Newton Rigg experiments, the hoggs fattened with turnips and hay alone gave an average live weight increase of 1½ lbs. per week, while those receiving about ½ lb. of cake and corn per head per day gave an increase of 2¾ lbs per head per week. The extra cake and corn very nearly doubled the rate of increase.

Useful Data from Feeding Trials.

The following particulars have been calculated from Mr Bruce's reports on the three years' (1903-6) experiments carried out by the Edinburgh and East of Scotland College of Agriculture. These results are important, seeing that a large number of sheep were experimented with each year, and the experiments were carried out in accordance with ordinary farm practice. Their value is therefore considerably enhanced.

PLATE XL.

In order to get average figures, the writer selected the four best lots in each year, and as the number of sheep varied from year to year, the results have been calculated per 100 sheep each year. The figures for the three years have been added together, and thus apply to a flock of 300 sheep. Roots have been charged at 10s. per ton; hay, £3 to £3, 10s.; the cake and meals at market prices during the three years.

Average Figures for Fattening a Flock of 300 Sheep on Roots.

	For 300 Sheep	If extended "at same rate" to slightly longer periods, would be for 300 Sheep.	
Duration of fattening period . . .	94 days	105 days	112 days
Cake and meal consumed . . .	20,417 lbs.	22,806 lbs.	24,326 lbs.
Roots consumed .	180 tons	201 tons.	214 tons.
Cost of hay, cake, and meal . . .	£69, 4s. 3d.	£77, 6s. 2d.	£82, 9s. 3d.
Cost of hay, cake, meal, and roots .	£159, 4s. 3d.	£178, 0s. 0d.	£189, 14s. 3d.
Live weight increase .	10,215 lbs.	11,411 lbs.	12,171 lbs.
Mutton produced, taking 68 per cent.* increase to be carcass .	6,946 lbs.	7,759 lbs.	8,276 lbs.
Increase in "value" of sheep . . .	£170, 9s. 0d.	£190, 8s. 0d.	£203, 0s. 0d.

* Lawes and Gilbert's figure.

The following average deductions can therefore be made:—

Hoggs can be fattened off on roots with cake and hay in thirteen and a half weeks; 2 lbs. concentrated food have given 1 lb. of live weight increase. Each sheep has consumed 12 cwts. roots during the average fattening period of ninety-four days, or 14⅓ lbs. per head per day. With a 20-ton crop, this is equal to 100 sheep for every 3 acres of roots.

Cost of hay, cake, and meal for ninety-four days was 4s. 7¼d. per sheep. With manurial residue taken into account, the cost would be 3s. 3d.; *i.e.*, 70 per cent. gross cost.

Cost of hay, cake, meal and roots for ninety-four days, 10s. 7½d. per sheep (9½d. per head per week); with manurial residue taken into account, 7s. 5¼d. (6½d. per week).

Each sheep has increased in live weight at the rate of 2·53 lbs. per week during fattening.

Cost of producing		14 lbs.	live weight	increase	was	52·37d.
"	"	100 "	"	"		31s. 2d.
"	"	112 "	"	"		34s. 11d.

With manurial residue taken into account, these figures would be 3s. 3½d., 21s. 9¼d., and 24s. 5¼d. respectively.

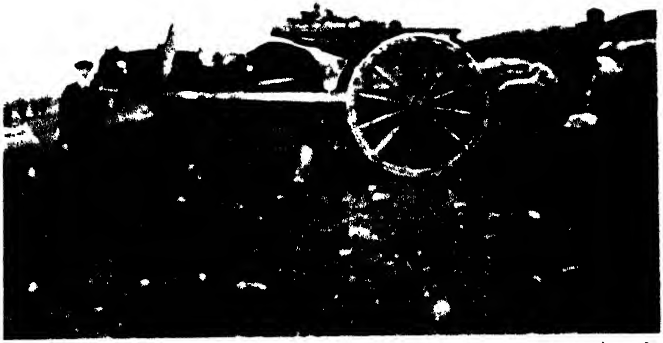
Each 1 lb.	of mutton	has cost	5½d.	to produce.
8 lbs.	"	"	3s. 8d.	"
15 "	"	"	6s. 5d.	"

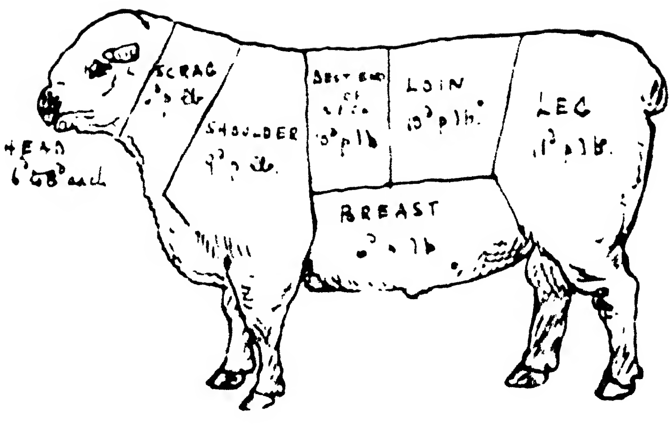
The sheep increased in value at the rate of 10¾d. per head per week during the time they were being experimentally fed, but one must bear in mind they were revalued at the beginning of the experimental period. These experiments also show that one can purchase store sheep at approximately the same price per pound as one expects to get for them live weight when fattened. The store price has varied from 4d. to 4¾d. per lb. live weight, and the sale price has come out exactly the same in 1903-4, and less than ¼d. per lb. difference in the other two years. The sheep weighed 9 to 10 stones live weight when fat.

The return for an acre (20 tons) of roots consumed, after paying for hay, cake, and meal at market price, comes out, on an average of the three years' experiments[1] with the four best lots, at £11, 1s. gross; or with the manurial value of the cake and hay taken into account, £12, 18s. 4d. per acre.

Some farmers consider that the cost of shepherding

[1] Edinburgh Agricultural College.




SCRAG
SHOULDER
BEST END
LOIN
LEG
BREAST
HEAD

for the winter month as well as the average loss are balanced by the manurial residue, while others allow 1d. to 2d. per head per week for the shepherd's wages, including removal of hurdles, troughs, carting hay, etc. For losses by deaths, etc., ½d. to 1d. per head per week is charged. These figures place the value of the manurial residue at from 2d. to 3d. per sheep per week, which is approximately 30 per cent. of the total value put on the food.

XXXIV. CARCASS COMPETITIONS FOR SHEEP.

The following table (pp. 286-7) gives the result of the carcass competitions at Smithfield Show in 1913. As column 1 was given in hundredweights, quarters, and pounds, and column 2 in Smithfield stones, it was considered advisable to calculate them both to pounds, so that the relation between live weight and dead weight may be all the more easily followed. Column 3 was then calculated to show the proportion of carcass to live weight.

The breed of each sheep is given, but, unfortunately, the exact age is not available. There are, no doubt, practical difficulties in recording the individual ages of sheep which are kept in large flocks, especially when they are intended to be fed off as early as possible for mutton.

XXXV. FEEDING OF PIGS.

The pig ought to occupy a more prominent position on many farms than it does at present. No other farm animal will give so large a return for the food consumed as the pig, hence it has been called the "most economical

Smithfield Show, 1918—Sheep. *Carcass Contests.*

BREED.	Live Weight.	Carcass Weight, less Allowance for Head & Feet.	Percentage of Carcass Weight to Live Weight.	Fat.	Pluck.	Skin.	Carcass Award.	Price per Stone (8 lbs.)
One Pure Long-woolled Wether Lamb not exceeding Twelve Months Old—	lbs.	lbs.		lbs.	lbs	lbs		s. d.
Cheviot	110	60	54·5	5	3½	15	1st	8 8
,, ...	109	64	58·7	4½	3½	13	2nd	6 0
,, ...	140	73	52·1	8½	4	16	3rd	5 2
,, ...	91	54	59·3	4	3	14½	4th	5 8
,, ...	118	67	56·7	5½	3	14	r.	5 8
,, ...	110	61	55·4	5	3	16	...	...
,, ...	93	59	63·4	4½	2½	12	...	...
Mountain	142	74	52·1	9	3½	23		...
One Pure Long-woolled Wether Sheep above Twelve and not exceeding Twenty-four Months Old—								
Cheviot	145	85	51·7	6	3½	15	1st & ch.	21 0
,, ...	138	77	55·8	6½	3½	20	2nd	6 0
,, ...	136	80	58·8	7½	3½	14	3rd	5 8
,, ...	133	77	57·8	6	3½	14	4th	5 6
,, ...	114	68	59·6	8	3	11	r. & h.c.	5 8
Welsh	142	85	59·8	12	4	12	c.	
Cheviot	137	82	59·8	6½	3½	15	c.	...
,, ...	143	84	58·7	8	4	15½	c.	...
Welsh	136	78	57·3	17	3	11½	c.	...
One Pure Short-woolled Wether Lamb not exceeding Twelve Months Old—								
Southdown	92	52	56·5	3	2	10	1st	11 0
,, ...	98	57	58·1	2½	3	10	2nd	29 8
Suffolk	150	86	57·3	7	4½	13	3rd	5 10
,, ...	118	64	54·2	6	3½	12½	4th	5 0

"	144	77	[illegible]	[illegible]	[illegible]	[illegible]		
"	177	106	59·8	9½	4½	14½	...	...
Southdown	114	64	56·1	6	9	14½	...	...
"	104	59	56·7	4½	3	11	...	...
One Pure Short-woolled Wether Sheep above Twelve and not exceeding Twenty-four Months Old—								
Suffolk	174	107	61·4	11	5	13	1st & r. ch.	8 0
Southdown	113	65	57·5	3	3	11½	2nd	7 0
Hampshire Down	149	90	60·4	7½	4½	13	3rd	5 6
Southdown	131	72	54·9	5	4½	12	4th	5 10
Suffolk	177	108	61·0	11½	4	14	...	...
"	229	137	59·8	17	5½	10½	...	...
"	183	107	58·4	14	4½	13	r.	4 4
Southdown	127	77	60·6	7½	3	11	...	...
One Cross-bred Wether Lamb not exceeding Twelve Months Old—								
Suffolk Cheviot	127	72	56·6	5½	4	14	1st	8 0
Southdown Hampshire	119	72	60·5	6½	3	13	2nd	6 4
Suffolk-Hampshire	127	72	56·6	6	4½	12	3rd	6 0
Suffolk Cheviot	115	66	57·3	5½	3	15	4th	6 0
Suffolk-Leicester Cheviot	138	78	56·5	4	4	10½	r.	5 8
Suffolk Cheviot	126	72	57·1	5	3½	13	...	...
Southdown Suffolk	156	96	61·5	10	4½	15½	...	...
One Cross-bred Wether Sheep above Twelve and not exceeding Twenty-four Months Old—								
Suffolk Cheviot	167	101	64·7	11	4½	13½	1st	6 8
Southdown Cheviot	142	87	61·2	8½	4	13½	2nd	5 2
Oxford Cheviot	195	117	60·0	11	5	26	3rd	4 0
Suffolk Southdown	154	90	58·4	7½	4½	13½	4th	5 0
Wensleydale Mountain	172	103	59·8	7½	5	20	r.	4 10
Suffolk-Leicester Cheviot	194	118	60·8	14½	5	16	...	...
" "	204	130	63·7	13½	5	20	...	...

meat-making machine at the farmer's disposal." It is a somewhat despised animal, because it readily accepts scraps of meat from the house, or, in some cases, the leavings of the well-fed bullock; but when properly fed and housed the pig supplies the finest bacon, which is so indispensable on the English breakfast table.

On many farms there are so-called "bare-periods," when there is little to sell. If, however, pigs are kept, it is possible to arrange matters so as to have a number of porkers or bacon pigs to sell at such times, which will largely overcome this difficulty.

Pigs also come in very handy for consuming and turning to profitable account the by-products of the dairy—skim milk, buttermilk, whey, house wash, etc.—as well as "brown" and small potatoes from the farm which have little commercial value. Tail oats, wheat, or barley can also be very profitably utilised for pig-feeding.

The first essential for winter pig-feeding is a comfortable house. The so-called "pig cot" is generally cold, wet, and dirty; in fact, a most unsatisfactory house for a pig. The best house is a small horse-box, which is warmer and much cleaner than the pig cot; pigs thrive better in it, and the box when empty can be utilised for all classes of stock.

The economy of keeping pigs in warm, comfortable boxes in winter is well emphasised by experiments conducted by Grisdale at the Ottawa Experiment Station, with pigs weighing on an average about 70 lbs. live weight. One lot was kept for sixty days during winter housed in ordinary wooden cabins, while the other lot was kept in the much warmer and more comfortable piggery at the Experiment Station. Both lots of pigs made approximately the same live weight increase, but

PLATE XIII.

those kept in the wooden cabins required 526 lbs. of meals to produce 100 lbs. live weight increase, while those in the warmer station piggeries required only 366 lbs. meals to produce the same increase, thus effecting a saving of 44 per cent. on the food consumed.

With brood sows, Grisdale found in a similar experiment that those kept in the wooden cabins during winter required 25 per cent. more food. In England the same thing holds good, although the difference may not be quite so great as in Canada, where the winter is very severe.

Feeding the Brood Sow.

Sows kept for breeding purposes should be descended from a strain which is noted for being good mothers of quiet disposition, and for having litters of eight to fourteen piglings of uniform size.

The sow should be of a good type, which means that the bones of legs should be fine, head and shoulders neat, with broad back, long deep sides, and heavy hind quarters. Care should be taken to avoid any sows which have been fed largely on flesh meat, as they are apt to worry their piglings at farrowing time.

There is generally a good demand for six- to ten-week-old pigs on dairy farms about May, to consume the dairy by-products, and on arable farms there is a similar demand in autumn to consume "brown" and small potatoes, etc.; hence sows should if possible be timed to farrow about February for spring demand, and late August or early September for autumn demand.

For two or three weeks after the sow has been weaned from her litter, continue the feeding in order to allow her to recover from the severe strain of nursing before mating her again. This treatment is considered

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to have the effect of increasing the size and evenness of the litter.

During pregnancy, it is a good plan to give the sow a run where she can get plenty of fresh air and exercise. An open shed in which she can feed, sleep, and find shelter is a great convenience. The food would vary somewhat with the time of year, but during first half of pregnancy period may consist of house wash or whey with some tail oats or barley meal in it. If necessary, some roots or other succulent food may be given.

For a couple of months before farrowing, the sow should receive a richer diet, in order to secure proper development of the young, and for this purpose some barley meal, ground oats, bran, etc., may be added to the diet.

About a week before farrowing, "guards" should be placed round the usual bed of the sow, about 7 inches high and 7 inches from wall, to prevent the sow squeezing her piglings to death against the wall. The box would be much better with the walls lime-washed, and the floor thoroughly disinfected.

Her diet should be somewhat restricted, and bran mashes given according to the necessities of the case. The bran mashes should be continued for a day or two after farrowing; after that they should be gradually fortified with scalded meals (sharps, maize, or barley meal, etc.), made into a thin slop with separated milk, house wash, etc., and fed warm.

Professor Henry states that a sow in full milk yields about 3 quarts milk per day, and during the whole suckling period something like 50 galls. Professor Davies (Wisconsin) estimates that one-third of the food goes to support the body of a milking sow and two-thirds for milk-production.

The sow should be turned into the field or other enclosure periodically to get fresh air and exercise, eat grass or other succulent foods, and any earthy matter which nature demands.

After nursing the piglings for six weeks, she should be taken away from them for gradually increasing periods each day, and weaned from them altogether at the end of eight weeks. The cost of keeping a breeding sow for a year varies considerably, but £6 may be taken as an average figure.

Feeding the Piglings.

Newly born piglings average about 2 lbs. live weight, and require no feeding beyond their mother's milk during the first three weeks. If the piglings have abnormally long teeth at birth which cut the sow's teats, they should have them nipped off short with a pair of sharp wire-cutters; otherwise there will probably be difficulty in rearing them.

At three to four weeks of age, the piglings show an inclination to eat, and should then receive in a small trough when the sow is out, a nice thin gruel made of scalded sharps, to which is added, after cooling, some new cow's milk, and fed four times a day. The amount of gruel given should be gradually increased as the piglings grow in size. A little bran should then be added to the sharps, and the whole cow's milk gradually substituted with skim or separated milk. The quantity fed each time should never exceed what they are able to clean up immediately.

In summer the piglings should be turned out into an enclosure to exercise their muscles, develop their limbs, and pick up grass as well as earthy matter, which appears to be necessary to keep the piglings in good

health. In winter, small coals, cinders, or a grass turf should be given to them in the pig-box. Precipitated chalk to the extent of ¼ to ½ oz. per head per day, may also be added to their daily food.

The piglings grow rapidly, and give a splendid return for food consumed, seeing that 3 lbs. of meal will easily give 1 lb. live weight increase. Professor Davies (Wisconsin) found by weighing piglings at 6.30 A.M. and 6.30 P.M., that 71 per cent. of the increase in live weight was made in the night, and only 29 per cent. in daytime.

Although good breeding is important with pigs intended for fattening, it has been said that "half the breed of a pig goes in at the mouth," which emphasises the importance of the care required in fattening pigs off rapidly and economically.

After weaning, the meal ration should be gradually increased both in quantity and variety, but maize meal should not be fed too freely to young growing pigs. Professor Fuller (Wisconsin) proved that maize alone was not a suitable food by itself for young growing pigs, on account of its lack of bone-forming material. He reared two lots, one with maize alone, and another with a mixture of maize meal, wheat middlings, and skim milk. The pigs fed on maize alone weighed at end of this experiment 84 to 103 lbs., and in the latter case 130 to 190 lbs. Further, the thigh bones of the mixed meal and skim milk lot were 50 per cent. stronger than those fed on maize alone.

If fed at all, maize meal should be fed in conjunction with foods which are both rich in albuminoids and mineral constituents, such as pea and bean meal.

The piglings may either be fed off at once for pork, or run on cheaply for a time and fed off later for bacon.

Store Pigs.

The system of allowing newly weaned pigs to "run on" is still practised to a large extent. The idea is, very largely, to feed them as cheaply as possible on a ration that will allow them to develop their muscles and grow bigger frames without fattening, so that at three, four, or five months old they may be either housed and fed off quickly for bacon by the breeder, or sold to farmers, managers of creameries, cheese factories, etc., who have dairy by-products at their disposal which can be utilised for this purpose.

The foods which are generally available for these stores in summer are grass, cabbages, clover, lucerne, and other green foods. In autumn they will pick up acorns, apples, etc., but some meal, along with house wash, whey, etc., should also be given daily. This system of feeding stores allows the pigs considerable freedom, and it is good policy to give most of the meal stirred into house wash, etc., at the end of the day, so as to train them to come home at night. The meals should simply be stirred into the liquid and given without any previous scalding at all.

In the winter there is generally on arable and mixed farms a plentiful supply of roots, *e.g.*, mangels, swedes, kohl rabi, potatoes, and tail corn, etc. The roots are best pulped, and the grain bruised. In cold weather, at any rate, the slop is best fed warm, otherwise some of the food is wasted in raising the temperature of the food up to body temperature. This may be done either by mashing the newly boiled potatoes up with the meals and feeding at once, or by adding water which is sufficiently warm to bring the mixture to body temperature.

XXXVI. FATTENING PIGS.

Where accommodation permits, it is a good plan to breed own pigs so as to obtain them at cost of production price. Piglings should not be allowed to lose their pigling flesh, but fattened off as quickly as possible.

During recent years the demand for heavy scaling pigs has largely declined, and, generally speaking, only those pigs which do not exceed 150 lbs. dressed weight are keenly sought after. Above this weight the price per stone diminishes in proportion to the amount by which the above weight is exceeded.

Early Maturity.—The smaller carcasses generally contain a larger proportion of lean meat, which is at the same time more juicy, and commands the top price when sold. Further, the increase obtained from a given weight of food is greater in the earlier stages of a pig's life than is the case when it is mature. The advantages consequently lie on the side of early maturity.

The following table gives the results obtained in Denmark (Copenhagen) from pigs which were fattened off at different ages:—

Size of Pig. Live Weight.	*Meal Equivalent to give 1 lb. Increase.	Size of Pig. Live Weight.	*Meal Equivalent to give 1 lb. Increase.
Up to 35 lbs.	3 lbs.	155 to 195 lbs.	4·66 lbs.
35 " 75 "	3·76 "	195 " 235 "	5·40 "
75 " 115 "	4·35 "	235 " 275 "	6·14 "
115 " 155 "	4·45 "	275 " 315 "	6·39 "

* The "meal equivalent" is obtained by taking 6 lbs. separated milk, 12 lbs. whey, or 4 lbs. boiled potatoes as being equal to 1 lb. meal.

These figures show that pigs over 200 lbs. live weight required double the amount of food to give the same unit increase in live weight as those which are under 35 lbs. live weight.

Pork Production.

Here it is important to get thick, well-made pigs with large, well-developed hind quarters. The selected breed should also be one that will grow and fatten at the same time, *e.g.*, Middle White Yorkshire, or crosses between Middle White and Berkshire or large White Yorkshire and Berkshire. The white boar used should be well bred, so as to impress his white colour on the offspring as far as possible.

The weaned pigs should be fed three or four times a day on bran and sharps mixed with skim milk. At about three months old one of the rations on p. 324 may be given at the rate of 1 to 2 lbs. meal per 100 lbs live weight. The food should be made into a thin slop during the early stages of fattening, but the amount of added liquid should be gradually diminished as fattening proceeds (see table below).

Professor Henry holds that if more than 1 gall. of separated milk is given to every 3½ lbs. meal, the results become much less satisfactory as the proportion of the liquid is increased.

In Denmark the fattening period is divided into four stages according to live weight, and the ration for each of these stages is stated in its meal equivalent; *i.e.*, 6 lbs. of separated milk is equal to 1 lb. meal, and so on. *E.g.*—

	Milk	Meals	Roots or Green Food.
I. Up to 40 lbs. live weight. Ration .	30 per cent.	70 per cent.	•
II. 40 to 60 lbs. live weight. Ration .	25 „	70 „	5 per cent.
III. 60 to 120 lbs. live weight. Ration .	15 „	75 „	10 „
IV. 120 to 200 lbs. live weight. Ration .	12 „	83 „	5 „

This means, so far as the separated milk and meals are concerned, that—

Up to ten weeks old, the meal is mixed at the rate of 4 lbs. to 1 gall. skim milk.

Ten to sixteen weeks old, the meal is mixed at the rate of 5 lbs. to 1 gall. skim milk.

Sixteen to twenty-four weeks old, the meal is mixed at the rate of 8 lbs. to 1 gall. skim milk.

Twenty-four to thirty-six weeks old, the meal is mixed at the rate of 6 lbs. to ½ gall. skim milk.

In this case the food is prepared a day ahead, and the meal consists of barley, maize, ground oats, and sharps. Pigs up to 60 lbs. live weight get charcoal, and when necessary for the bowels, a little cod-liver oil. The various green crops, including roots, should be fed to the pigs, if available, in the earlier stages of fattening, but this should be gradually reduced as fattening advances.

On the London market the small porkers at four to five months old, and weighing 60 to 70 lbs. dressed weight, meet a ready sale and fetch the highest price per stone. In the North of England the demand is for a larger pig, scaling 140 to 150 lbs. dressed weight. This weight can easily be obtained by the time the pig is seven months old.

Financial Aspect of Breeding for Pork Production.—Although breed and type are important in selecting sows for breeding pigs for pork production, it is no less important to secure the sows or gilts from a strain which is noted for having medium sized litters of strong, healthy pigs. A few simple calculations will show the necessity of taking this step: *e.g.*, a sow usually has two litters a year, and if we assume that it costs £14 a year to keep a sow, and provide for depreciation, risk,

and other costs up to the time the pigs are weaned at, say, eight weeks old, this will mean that £7 must be debited against each litter.

The pigs may be fattened indoors and sold off as:—

(1) London porkers at an age of fourteen weeks, weighing, say, 5 stone of pork;
(2) At sixteen weeks old, weighing, say, 6½ stone of pork;
(3) At twenty weeks old, weighing, say, 9 stone of pork.

Then, assuming an outlet for each kind, at what age will it pay best to market them, and what size of a litter is the most profitable, or can I afford to keep sows that have small litters?

The average costs of rearing and fattening off pigs from various sized litters can now be calculated, by charging £7 against each litter for the keeping of the sow, allowing an average of 3 lbs. of meal each for pigs eight to fourteen weeks old, and 4 lbs. meal each for pigs fourteen to twenty weeks old. Charge meals consumed at 1¼d. per lb. Allow 3s. per week for proportion of man's time in feeding a litter, as well as, say, 15s. per litter for marketing expenses. The following figures would then give average costs of rearing and feeding a pig from different sized litters for pork:—

Size of Litter	Sold at 14 Weeks old			Sold at 16 Weeks old			Sold at 20 Weeks old		
	£	s.	d.	£	s.	d.	£	s.	d.
Four . . .	2	16	4	3	3	8	3	18	4
Six	2	1	11	2	8	9	3	2	5
Eight . . .	1	14	9	2	1	4	2	14	6
Ten . . .	1	10	5	1	16	10	2	9	9

The possible return can be seen from each of these groups, by the aid of a simple form of ready reckoner, *e.g.*—

Sale Price	[illegible] Stone Pork	[illegible] Stone Pork	[illegible] Stone Pork
	£ s. d.	£ s. d.	£ s. d.
7s. per stone	[illegible]	[illegible]	3 3 0
8s. "	2 [illegible]	2 12 [illegible]	3 12 0
9s. "	2 [illegible]	2 [illegible]	4 1 0
10s. "	2 [illegible]	3 [illegible]	4 10 0
11s. "	2 [illegible]	[illegible]	4 19 0
12s. "	3 [illegible]	[illegible]	[illegible]

It will be noticed that the "four litter" pig is not a paying proposition except when pork is selling at a minimum price of 12s. per stone, whereas the "eight-litter" pig will leave a profit at 8s. per stone. The "ten-litter" pig will leave a margin, even when pork is 7s. per stone. Further, the 5-stone porker does not appear to leave as much margin for profit as the larger sized porkers mentioned above.

Bacon Pigs

The term "bacon pig" is generally applied to those which are sold off fat, when they have attained a minimum live weight of 2 cwts., or, say, 150 to 160 lbs. dressed carcass. For bacon it is not so important to have short, thick pigs with well-developed joints, but what is required is a big-framed body with long and deep sides, so as to give as large sides of bacon as possible, containing a good proportion of lean meat. Store pigs intended for bacon may be reared or bought.

Breeding Stores.—The pigs which were reared on the farm would, no doubt, be weaned about eight weeks old, and be left out in the field during the summer

months, provided they had a shed in which to eat and sleep. In the field they would get plenty of green, succulent food (grass), and with a morning and evening ration of, say, 1 to 1½ lbs. meals allowed each time, stirred into some skim milk, whey, house wash, etc., they would grow big frames and develop their muscles.

At three to four months of age, the pigs should be put up to fatten, and be fed with some succulent foods such as pulped potatoes, swedes, mangels, green vetches or clover, cut cabbages, etc., depending on time of year, in addition to skim milk, whey or buttermilk, and meals. The food should be fed warm (say [illegible] F.) during the fattening period, otherwise part of the food has to be utilised to raise the food to the temperature of the body, leaving a smaller surplus for the formation of flesh, fat, etc.

As fattening proceeds, the green or succulent part of the ration given each day should be gradually reduced, and scarcely included in the ration at all during the last three or four weeks of the fattening period. The meals, which probably constitute a third part by weight of the roots or succulent food given, need to be gradually increased. At the same time, the amount of liquid added to meals to make them sloppy should be gradually reduced in quantity, from 1 gall. to, say, ½ gall. per head per day. Too many roots or boiled potatoes make the flesh lacking in firmness, and the proportion of fat to lean meat too high. The liquid part of ration should gradually be reduced so as to get the increase of a much drier nature before the animal is killed. After two to three months of fattening (say, six months old) the pig will be 150 lbs. to 170 lbs. carcass weight.

In Wiltshire, ½ gall. of raw linseed oil per day is added for every sixty-four pigs, in the food, in order to keep their bowels in order.

In Berkshire it is a common practice to sour the food (*i.e.*, soak it for a few hours until it begins to ferment) before feeding to the pigs, the idea being that the pigs fatten better and are less liable to suffer from costiveness.

Buying Stores.—In Wiltshire, store pigs are usually bought when they are about four months old, or a live weight of 90 to 140 lbs. These are fed for seven to fourteen weeks on such a ration as separated milk, barley meal, and boiled potatoes, and killed off fat at a live weight of 133 to 230 lbs. These may increase in live weight at the rate of 2 lbs. or over per head per day.

In "winter" the roots given will consist of boiled potatoes, pulped mangels, swedes, or turnips, and chopped cabbages; while in "summer" the succulent food will be derived from grass, green vetches, and other forage crops. Both in summer and winter economy should be studied, and any by-products made use of. There are many foods on a farm which are most useful for fattening purposes, although their market value is not high—*e.g.*, "tail" corn (cereal grains), small and brown potatoes, green forage crops, skim milk, buttermilk, house wash, and whey.

Open-Air Systems of Pig-Feeding.

The different Breed Societies have generally placed in the forefront one common point which should characterise a perfect specimen of any particular breed, viz.: a good or strong constitution. Attempts

to retain strong, healthy, vigorous pigs in continued confinement indoors have conspicuously failed, so far as pedigree breeding is concerned. If one only follows the methods adopted by the most successful pedigree breeders, one will soon discover that their breeding animals have been kept in the open air as much as possible, in order to keep them active, thus enabling them to inhale more oxygen from the air, and digest their food better, develop their muscles, or, "in a word," develop strong and healthy constitutions.

A far-seeing poet applied the same principle to human beings when he wrote:—

> "By chase our long-lived parents earned their food,
> Toil strung their nerves and purified their blood.
> But we, their sons, a pampered race of men,
> Have dwindled down to three-score years and ten.
> Better to hunt in fields for health unbought,
> Than fee the doctor for a nauseous draught.
> The wise for health on exercise depend,
> God never made his work for man to mend."

It will now be convenient to follow up some of the older methods of keeping pigs outdoors, before dealing with arable pig farming, etc.

1. Grazing in Standard Orchards.—Adjoining the farmyard is usually a standard orchard with grass under the trees. On account of its proximity to the sty, the orchard has been used for many years as an exercising ground for pigs, and a place where they could obtain green food. In some cases they were turned out periodically, say once or twice a week, while in others they were practically allowed to live out during the summer months, except that they were housed each night. The net result was that the pigs were healthier, required much less meal, and produced stronger litters.

Incidentally, the orchard trees benefited considerably from the manure left by the pigs.

In a similar way, pasture fields adjacent to the farmyard have been used as exercising grounds and places where pigs could get any green food and earth they required. On good pasture, the amount of meals required by the pigs to give 1 lb. live weight increase may be reduced to one-half or even more than is required in sty-feeding.

2. Grazing Corn Stubbles, etc.—In the autumn after the "corn" is harvested, pigs are often allowed to róve over the farm, where they eat shed corn on the stubbles, acorns, beech mast, etc. During this period they need very little hand-feeding, beyond what is given to induce them to turn up to the sty at night. By this means, much food which would otherwise be wasted is secured by the farm animals.

3. Utilisation of Woodlands.—Many farms in Great Britain include a proportion of woodland, which, so far as most tenant farmers are concerned, act as windbreaks, but beyond that are little more than breeding grounds for rabbits, etc. Some of the more progressive farmers, however, utilise their woodlands for pig farming. An interesting account of Mr S. F. Edge's method is given in the *Journal of the Ministry of Agriculture* for January 1916. The main points are as follows:—

1. The pigs are farrowed in huts in small enclosures of woodland.
2. At weaning time, pigs are removed to larger enclosures and left in lots of 30 to 40 pigs.
3. After a week or two, any pigs unfit for pedigree purposes are taken into sties, fed off for porkers of approximately 100 lbs. live weight, and sold

from September to April. When they are not sold as porkers, they are kept on and sold for bacon at a live weight of about 220 lbs.

4. About a month after weaning, separate boars from gilts, and from this time onwards, till wanted for breeding or sale, they are kept in enclosed areas in the woodlands in lots of 12 to 40, depending on the age of the pigs.
5. Up to four months old, the pigs are given sharps, in addition to the food they pick up in the woods; but after that, peas or beans are added to the sharps in the proportion of about one part of the former to two or three parts of the latter. When green food is scarce, mangels, cabbages, or lucerne is given in strictly limited quantities.
6. The runs are rested three months each year, and once a year the smaller farrowing enclosures are limed. In the spring, during the resting period, a little clover and rye grass is sown.
7. During the winter time, all larger gilts and sows from twelve months upwards are rung, and then allowed to roam over grass-land. The grass-land benefits from the manure, and where the land has been mole-drained and dressed with basic slag, poor pastures are rapidly improved. The pigs are attracted to thin patches by scattering a few peas or beans.

Mr Edge finds the large black pig very suitable for this purpose. The breeding pigs are more prolific, better mothers, and hardier than sty-fed pigs. Further, seeing that primitive shelters are used, and waste or poor land is being utilised for the purpose, the

transaction is much more profitable than sty-feeding. Another advantage is that the pigs keep down various weeds by grazing and rooting, which may otherwise tend to seed the farm.

Mr Timberlake, Hastoe, Tring, utilises his woodlands for pig rearing in a similar way, except that he keeps the pigs in much larger herds. The breed kept in this case is the Middle White, which thrives amazingly on this treatment.

4. Grass-land Pig Farming.—The term "Grass-land pig farming" is being used for those systems where the pigs are bred, housed, and allowed to graze freely, within the area hurdled or netted off, on the grass-land. For this purpose, a given pasture field may be kept grazed in at least two ways:—

(1) The field may be divided, more or less permanently, into a number of pens varying from ½ to 2 acres or more in size. The ½-acre pens are fine for sows farrowing down and rearing her litter till weaning time, while the 2-acre pens might carry, say, six to ten gilts or young boars; the object being to put sufficient pigs in each pen to keep the grass reasonably well grazed down. The pig-houses are simply shelters against bad weather, and are constructed as cheaply as possible. The grass ration is supplemented by whole grain or meals given generally in some form of dry-feeder. Drinking water must be supplied to the pigs. Where large numbers of pigs are kept on this system, it is sometimes advisable to lead water to the different pens and supply automatically all the water required.

(2) The pigs are kept in small pens, which are moved on systematically till the whole of the field has been grazed, and incidentally manured. This method is very suitable for rough pastures which require grazing down, or on some of the poorer pastures which require renovating. Mr Atkinson, Little Hampton, Bucks, has an interesting method of improving his poor pastures with pigs. The pigs are penned on the ground to graze down cocksfoot and other grasses, etc., and given a small allowance of meals a day before they are moved on to fresh ground. A simple pasture renovation mixture containing, say, ½ to 1 lb. wild white clover, is sown over the ground, so that the pigs will tread the seed in before being moved on. In this way, poor pastures can be rapidly improved.

For open-air grazing, it is important to select pigs from a breed and strain that has been accustomed to open-air conditions. All the black breeds appear to be natural grazers. Pigs bred and reared under open-air conditions learn to graze at an early age, and with very little meal, make rapid progress, the best pigs being ready to sell off as porkers in autumn; whereas the remainder could be kept on until sold off for bacon. The meal allowed on good pasture would be roughly 2 to 3 lbs. per 100 lbs. live weight, and the gain in weight expected should be about 1 lb. per pig per day.

Some farmers feed whole grain, *e.g.*, maize, oats, etc., instead of meals, in order to save labour, and the pigs do not find any great difficulty in dealing with whole

corn. The whole grain is generally dropped in a narrow row from a bag.

Mr Bostock Smith appears to get good results by feeding maize and beans sprouted. These are soaked in water for twenty-four hours and the water drained off. The grain is then placed in a heap on a hard floor and covered with a sack. After they have germinated they are scattered on the grass-land, as the pigs tend to gorge themselves when the soaked grains are placed in troughs. These soaked grains may be fed to pigs over sixteen weeks old, or to gilts till farrowing time. This method is more suited to the warm months of the year, as the grain does not sprout readily in winter, unless a warm building is available for the purpose.

As to the relative merits of these two methods, the fixed pen involves more initial expense in hurdles or pig netting, but after that there is practically no labour or expense in this respect; whereas in the movable pen method, less initial expense is required in hurdles or pig netting, but the regular moving of the pen on to new ground involves extra labour.

A defect of the fixed-pen method is that the grass may become "fouled" with pig manure, unless the pens are rested periodically; while in the moving-pen system this danger is avoided. In both systems it is found that, where the pens are too small, there is a tendency for the pigs to leave most of their droppings alongside the fence.

5. Arable Pig-Farming.—During the last few years a great development in arable pig farming has taken place, which was partly, if not largely, due to mutton production being a comparatively poor paying proposition, and arable pig-keeping was an alternative method of manuring the land. Arable pig farming means that

pigs are housed, kept, and provided for on the arable land, with the exception of meals required to supplement the forage crops consumed. The general practice is to fold the pigs on forage crops in movable pens, in exactly the same way as folding sheep on arable land. The main difference, so far, in providing arable crops for pigs as compared with sheep, is that in the former case leaf crops only are grown for the purpose, while in the latter case root crops in addition to leaf crops are provided.

Suitable forage crops are as follows :—

1. *Single Crops.*—Marrow stem kale, thousand headed kale, rape, cow cabbages, red clover, vetches, lucerne.

2. *Mixtures.*—

   (*a*) ½ bus. oats, 8 lbs. red clover, and 3 lbs. rape, each per acre.

   (*b*) 1 bus. oats, 1 bus. maple peas, and 3 lbs. rape, each per acre.

   (*c*) 1 bus. rye and 1 bus. tares.

   (*d*) 1 bus. tares and 1 bus. field beans.

   (*e*) 1 bus. oats and 1 bus. maple peas.

One advantage of using cruciferous forage crops is that the cost of seeding is comparatively small. At the same time the kales, cabbages, etc., give relatively large crops of green food, which no doubt accounts for the kales, more especially marrow stem, being favourite crops for this purpose.

Forage Crops all the Year Round.—For arable pig farming, it is important to provide for a continuous supply of forage crops, and this may be accomplished on the following lines :—

(a) *For Spring Grazing* (*i.e.*, March to May inclusive).[1]

Crop.	Quantity per acre.	Time to sow.	Ready to graze.
1. Thousand-head kale or cow cabbage	4 to 6 lbs.	July	Early spring.
2. Winter oats / „ tares	1 bus. / 1 „	September	Late spring.

(b) *For Summer Grazing* (*i.e.*, June to August inclusive).

Crop.	Quantity per acre.	Time to sow.	Ready to graze.
3. Winter oats / „ tares / „ beans	1 bus. / 1 „ / ½ „	October	Early summer.
4. Rape	6 lbs.	May	Late summer.

(c) *For Autumn Grazing* (*i.e.*, September to November inclusive).[2]

Crop.	Quantity per acre.	Time to sow.	Ready to graze.
5. Rape	6 lbs.	June	Early autumn.
6. Marrow-stem kale	4 to 6 lbs.	Late February or March	Late autumn.

(d) *For Winter Grazing* (*i.e.*, December to February inclusive).

Crop.	Quantity per acre.	Time to sow.	Ready to graze.
7. Marrow-stem kale	4 to 6 lbs.	April and May	Early winter.
8. Thousand-head kale	4 to 6 lbs.	May and June	Late winter.

Kales and cabbages may yield 20 tons or more per acre of green food; rape, as well as the vetch mixtures, 15 tons or more per acre. One may assume that an acre of rape or vetch mixtures will carry twelve to twenty pigs of 100 lbs. live weight for four weeks, and that one acre of kales or cabbages will carry sixteen to twenty-six pigs for the same period.

In order to get young pigs to take kindly to eating forage crops, it is advisable for them to be farrowed on

[1] In some cases one may allow pigs to graze "winter-proud" corn during the spring months.

[2] After harvest pigs could be allowed to pick up "shed" corn on the stubbles.

the arable land and allowed to graze from the beginning. At weaning time the sow should be moved away and the piglets left, with the result that the piglets do not upset themselves, as they would do, if moved to fresh surroundings.

Supplementary Meal Rations.—In arable pig farming, it is usual to feed the meals in a "dry-feeder," and for this purpose rations 4, 8, 9, and 10 (p. 324) would be quite suitable, provided approximately 5 per cent. of white fish meal were added. The quantity of meal allowed should be limited to about half or three-quarters the quantity fed to pigs indoors of similar age, *i.e.*, 2 to 3 lbs. per 100 lbs. live weight. With this allowance plus green food, the pigs should increase in live weight ¾ to 1 lb. per head per day.

Stanley Wilkin, Tiptree, can produce, under arable conditions, a porker of 112 lbs. live weight in thirteen weeks, and a baconer of 194 lbs. live weight in twenty-five weeks.

Mr Bostock Smith and Mr S. F. Edge favour using dry-feeders with several compartments which will admit of each different food being placed in a separate compartment. The pigs are then left to select the foods and arrange the ration for themselves. Many feeders give small quantities of steam bone flour and other mineral salts to meet the mineral requirements of the body. Pregnant sows may be allowed, in some cases, a little cod-liver oil in their meal mixture, in order that they may store up in the unborn piglets an adequate supply of fat soluble A vitamin.

Mr Bostock Smith finds it advisable to bring open-air pigs inside or into confinement during the last three weeks of fattening, where they can be fed on "wet" food.

Housing.—The tendency is to house the pigs in the simplest and most inexpensive manner possible, combined, however, with some suggestion of order and tidiness. The houses used in many cases are merely shelters made with a framework of sheep hurdles, covered round the sides and on the top with straw or similar material.

The *advantages of arable pig farming*, as compared with indoor methods, are as follows:—

1. Reduced cost of food, owing to approximately half the indoor ration of meals being replaced with green food.
2. Saving of labour and attendance. With dry-feeders the chief daily requirement is 1 to 2 gallons per head per day of drinking-water, or even more.
3. The pigs are healthier
4. The arable land benefits from an even manuring. On dry, chalky, or sandy arable fields, a good, even dressing of pig manure appears to be one of the most effective ways of restoring the fertility.
5. The pigs may help considerably in keeping down weeds on the arable land that is grazed.

XVII. FEEDING EXPERIMENTS WITH PIGS.

It will now be interesting to examine any experimental evidence there is available, with regard to the suitability or value of various foods for fattening of pigs for the production of bacon.

(a) Liquids

Separated Milk v. Whey.—Kellner gave the comparative values of these two foods as 8 to 6—*i.e.*, the value of the former was one and one-third times as great as the latter.

In the West of Scotland Agricultural College experiments at Kilmarnock (1905-8), the relative values came out as 8¼ to 6, which come very near Kellner's figures.

The Danish standard for these two liquids gives separated milk double the value of whey for fattening purposes (*i.e.*, 6 lbs. skim milk, or 12 lbs. whey are equal to 1 lb. meal). This difference is most likely due to the fact that in the Kilmarnock experiments skim milk and whey were fed in approximately equal quantities per head per day, whereas in Denmark only half the quantity of skim milk is given as compared with whey. Few pig-feeders would be able to make an average daily allowance of 4 galls. separated milk per head, as half of this is generally considered liberal; consequently the Danish figure had better be adhered to in this case for skim milk, viz., that it is double the value of whey. At the Central Experimental Farm, Ottawa, 6 lbs. separated milk was found to be equivalent to 1 lb. meal, which confirms the Danish figure.

The equivalent of whey in terms of barley meal, in the Kilmarnock experiments, gives the figure 13 lbs. whey (1¼ galls.) as being equal to 1 lb. meal. The Danish equivalent for whey is 12 lbs., hence they agree very closely.

Separated Milk and Meals.—In the Wilts County Council experiments the object was to find the most

suitable food for producing the finest bacon. In order to facilitate comparison, the "meal equivalents"[1] of the various rations are given, which show the amount of food required to give unit increase :—

Ration.	Barley Meal Lot.		Maize Meal Lot.	
	Dressed Weight	Live Weight.	Dressed Weight.	Live Weight.
	lbs.	lbs.	lbs.	lbs.
Barley alone or maize alone . .	5·77	4·67	5·68	4·92
„ or maize + cooked potatoes	5·26	3·90	5·78	4·50
„ „ + separated milk .	5·72	4·46	4·83	4·05
„ „ + separated milk + cooked potatoes . . .	5·14	3·93	4·59	3·76

The above table shows that, with a mixture of barley or maize meal with either cooked potatoes or separated milk, less food is required to give unit increase in live weight than was the case with meal alone. In the case of the lot of pigs receiving barley meal, separated milk, and cooked potatoes, a "meal equivalent" of 3·93 lbs. gave unit increase (1 lb.). When, however, maize was used in place of barley meal, 3·76 lbs. meal or its equivalent gave the same result.

Barley meal and cooked potatoes gave better results than barley meal and separated milk, while with maize meal the reverse was the case, possibly due to the potatoes depressing the digestibility of the maize.

Danish experiments have shown again and again that for bacon production, skim milk, cooked potatoes, and meals give excellent results.

Whey and Meals.—Much light has been shed on this point by the Kilmarnock experiments, the results of which are given in the following table :—

[1] See p. 122.

Ration.	Meal Equivalent to give 1 lb. Increase in Live Weight.	
	1907.	1908.
	lbs.	lbs.
Whey alone	5·11	4·10
" and maize meal	4·44	4·29
" and barley meal	4·61	4·66
" and maize meal (1st period of fattening) " maize, and barley meal (2nd period of fattening) " and barley meal (3rd period of fattening)	4·59	4·44
" and barley meal (1st period) " barley, and maize meal (2nd period) " and maize meal (3rd period)	4·32	4·39

This shows that whey and maize meal give a useful combination of foods so far as live weight increase is concerned.

Barley and maize meals with whey have given very good results. When increase alone is taken into account, it appears best to commence with barley meal and gradually substitute it with maize meal. The chief drawback is, the maize tends to give a yellowish coloured flesh.

In 1909 and 1910, mixtures of barley meal with maize, and barley meal with rice meal, were both fed with whey, when the following meal equivalents were required to produce 1 lb. live weight increase:—

	1909	1910
	lbs.	lbs.
Whey, barley meal, and maize meal	3·27	3·41
" " rice meal	4·84	3·41

In 1909, barley meal and maize meal gave very much better results, but in 1910 there was little difference.

It was found possible to increase the live weight of the pigs from 100 to 210 lbs. in nine to ten weeks by feeding with separated milk and barley meal. When the ration was whey and maize meal, it required eleven weeks to produce the same increase. The proportion of maize to whey which gave best results was 2 lbs. meal to 2½ galls. whey.

(*b*) Root Crops.

Mangels and Meals.—In the Wiltshire County Council experiments the following results were obtained, and have been calculated to the meal equivalents required for 1 lb. live weight increase:—

Ration.	Meal Equivalent to give 1 lb. Increase.	
	Dressed Weight	Live Weight
	lbs.	lbs.
Maize and beans	5·17	4·04
„ beans, and mangels	5·02	3·95
„ and peas	5·26	4·11
„ peas, and mangels	5·70	4·41
„ and oats	7·11	5·36
„ oats, and mangels	5·86	4·63
„ and mangels	8·16	6·67
„ and potatoes	5·78	4·50

Live weight increase was produced with a lower meal equivalent when mangels were fed with either maize and beans, or maize and oats. With maize and peas the reverse was the case. With maize meal alone, mangels did not produce live weight increase with so low a meal equivalent as was the case with cooked potatoes.

Cooked *v.* Raw Potatoes.—Experiments carried out during recent years have had the effect of causing

some feeders to discontinue the practice of cooking foods for pigs. A common opinion at the present time is, that potatoes are practically the only food generally used for pigs that should be cooked.

Professor Brynner Jones, in his third Annual Report (1907-8), gives the results of an interesting experiment to determine the relative value of raw and cooked potatoes. The average daily ration consisted of $2\frac{3}{4}$ lbs. potatoes, 2 lbs. mixed barley and maize meals, "the food being given cold," along with sufficient water to make it of suitable consistency: the total live weight increases were as follows:—

	Cooked Potatoes.	Raw (Pulped) Potatoes.
	lbs.	lbs.
1st experiment—five pigs fed for eight weeks .	154	123
2nd ,, ,, ,, six ,, .	127	108
Total live weight increases . . .	281	231

The lot receiving cooked (boiled) potatoes gave 50 lbs. greater live weight increase, but the value of this increase is largely swallowed up in the cost of cooking potatoes. It should be noticed that the food was given "cold." Curiously enough, Mr Stevenson in the Kilmarnock experiments got better results with raw than cooked potatoes when fed along with an average daily ration of $2\frac{3}{4}$ galls. whey, $2\frac{9}{16}$ lbs. maize and barley meals, and $2\frac{3}{4}$ lbs. potatoes. In the case of raw potatoes a meal equivalent of 3·75 lbs. was required to give unit increase in live weight, while with cooked potatoes a meal equivalent of 4·16 lbs. was required to give the same increase.

Professor Henry (Wisconsin) found, with a ration where the proportion of maize to potatoes was as 1 : 3, that 4·42 lbs. cooked potatoes were equal to 1 lb. maize meal; while in Denmark, Fjord of Copenhagen showed that 4 lbs. cooked potatoes were equal to 1 lb. meal. The Danish standard gives a higher value to cooked than raw potatoes. According to their standard, 1 lb. of cooked potatoes is equal to 1¼ lbs. raw potatoes.

Professor Brynner Jones had the cooked potatoes fed "cold" in the above experiments, and it is possible that the good results attributed to cooking potatoes are largely due to the practice of mashing the cooked potatoes up with meals, and feeding the mixture "warm," in the form of a moderately thin slop or gruel.

At Kilmarnock, Mr Stevenson shows that food fed warm gives a larger live weight increase than food fed cold. Pigs receiving whey and Paisley flour required the following "meal equivalents" to give 1 lb. live weight increaso :—

How Fed.	Meal Equivalent to give 1 lb. Increase in Live Weight.
	lbs.
Cold	7·04
Warm	6·26

Winter v. Summer Fattening.—In 1894 the Copenhagen Experiment Station published a Report (No. 30) of 199 feeding trials with 2500 pigs, part of which number had been fed in summer and part in winter. The ordinary rations were fed, viz., separated milk, whey, roots, and meals, and these have been reduced to their meal equivalent :—

Live Weight in Pounds of Pigs.	Meal Equivalent to give 1 lb. Increase in Live Weight.	
	Summer.	Winter.
	lbs.	lbs.
35 to 75 lbs.	3·46	3·71
75 " 115 "	3·97	4·46
115 " 155 "	4·57	5·16
Average meal equivalent to give 1 lb. live weight increase	4·00	4·44

These results indicate that ½ lb. less meal is required on an average to produce unit live weight increase in summer than winter, hence it is more economical to fatten pigs in summer.

(c) Pig Meals

Barley meal and maize meal are very common constituents of pig meals, consequently the following table (p. 318) has been calculated from Mr Corbett's 1898 Report of the Wiltshire Experiments. The table shows what combinations from other sources were employed with barley and maize meals respectively, and with what results. The meal equivalent for the whole ration has been calculated on the Danish system (see p. 121). The results are shown in the table, p. 318.

The figures show that maize meal has given better results than barley meal, except in cases where these foods were fed with cooked potatoes only, when barley meal did much better than maize meal. This conclusion is supported by the Kilmarnock experiments.

In both cases the results show that for bacon production, both maize and barley meals are improved when blended with foods fairly rich in albuminoids, but at the same time poor in oil and low in fibre.

Foods given along with Maize or Barley Meals	Meal Equivalent to give 1 lb. Increase.			
	Maize Meal Lot.		Barley Meal Lot.	
	Dressed Weight.	Live Weight.	Dressed Weight.	Live Weight.
	lbs.	lbs.	lbs.	lbs.
Separated milk and cooked potatoes	4·59	3·76	5·14	3·93
Separated milk	4·83	4·05	5·72	4·46
Bean meal and mangels . .	5·02	3·95	...	...
Bean meal	5·17	4·04	...	...
Pea meal	5·26	4·11	...	...
None (maize or barley meal alone)	5·68	4·92	5·77	4·67
Pea meal and mangels . . .	5·70	4·41	...	...
Cotton cake and treacle . . .	5·71	4·36	...	...
Bran	5·73	4·67	6·07	4·32
Cooked potatoes	5·78	4·50	5·26	3·90
Ground oats and mangels . .	5·86	4·63	...	...
Ground oats	7·11	5·36	...	...
Mangels	8·16	6·67	...	...
Maize germ	...	...	5·99	4·78

(*d*) Wet *v.* Dry Feeding.

Green and Richardson[1] found in their pig-feeding trials that when pigs were fed three times a day indoors, there was practically no difference in the results of feeding meals dry and of steeping them before feeding.

Further, for fattening pigs outdoors, the system of dry feeding with unlimited rations has been more profitable than the method of feeding steeped food three times a day.

(*e*) Indoor *v.* Outdoor Feeding.

Green and Richardson[1] fed two lots of pigs from June to December in order to elucidate this point, when

[1] Report on Pig-feeding Trials—Lancashire County Council, 1920-23.

the amount of pork produced as well as the meal equivalent were as follows :—

	Pork produced per Pig.	Meal Equivalent to produce 1 lb. Pork.
	lbs.	lbs.
Lot I.—Outdoor pigs .	138	6·67
Lot II.—Indoor pigs .	148	6·14

The conclusion arrived at was that during autumn and early winter, it has been more profitable to fatten pigs indoors than outdoors.

(f) Fish Meal as a Pig Food.

Green and Richardson[1] showed that when fish meal was included, less food was required (viz. 4·05 lbs. as against 4·4 lbs.) to produce 1 lb. live weight increase.

Compared with oatmeal, the oatmeal ration produced a rather better bacon than the one containing ⅛th fish meal; but the cost of producing 1 lb. pork was higher with oatmeal ration (6¼d.) than it was with the fish meal ration (5½d.).

Compared with whey, fish meal has not been so effective as whey in giving "bloom" to pigs, but it prevented lameness or cramp, and on this account has been more profitable. During the whole experimental period one gallon of whey has been equal to one pound of meal.

Foods and Quality of Bacon.

The flesh of the fat pig intended for bacon should be firm in all parts, with a good proportion of lean meat to fat in the carcass. The fat should also be a clear white colour. The flesh of the pig is naturally

[1] Report on Pig-feeding Trials—Lancashire County Council, 1920-23.

rather soft (cattle and sheep just the opposite), hence foods are required which are poor in oil and rich in carbohydrates, *e.g.*, barley meal, pea and bean meal, etc. Kellner found that pigs kept in cold surroundings produce an oily fat, while a firmer fat was produced when pigs were kept warmer. A warm, comfortable box is therefore a very important point.

Soft Bacon may be produced by feeding large quantities of roots or other green foods during the later stages of fattening. These make the proportion of fat to lean too large, and at the same time give a soft flesh.

Generally speaking, concentrated foods containing 5 per cent. or over of fat give a soft bacon when they are fed alone to pigs. A very common example is maize meal, which gives a soft, yellowish fat. Professor Henry states that the lard of pigs fed on maize may contain 92 per cent. olein (liquid fat), while that from similar pigs fed on ground oats, pea and barley meals, may only contain 67 per cent. olein. Maize meal, however, gives rapid increases in live weight, and where the purchaser is unwilling to give more per pound for high quality bacon, its use will naturally be continued for bacon production.

Other pig-foods fairly rich in oil are linseed cake, rice meal, wheat bran, brewers' grains, distillery waste, oatmeal, fish, etc. These should not usually constitute more than a quarter to a third of the total meals fed, the remainder consisting of meals which are low in oil.

Soft bacon may also be caused by keeping the pigs short of exercise, marketing them before they are finished, too long after finishing, or by undue forcing.

The Wiltshire experiments showed that cooked potatoes and maize meal decreased the proportion of best pigs. Neither in the Wiltshire nor Kilmarnock

experiments did maize alone give such a high proportion of best pigs as barley meal.

Firm Bacon.—Roots and green foods should be gradually reduced in the later stages of fattening; in fact, they may be discontinued altogether during the last two or three weeks of the fattening period. The liquid portion of ration should also be gradually reduced, until the meals in it make it quite a thick slop by the end of the fattening period. This method appears to rid the tissues of excess of water before the animal is killed, thus giving a firmer bacon.

Firm bacon is produced by those concentrated foods which are poor in fat and fairly rich in albuminoids; *e.g.*, barley meal, skim milk, pea meal, bean meal, etc. Pea meal and bean meal are rich in albuminoids, and if fed in excess of 3 or 4 lbs. per head per day, would probably produce flesh which was too firm. Barley meal and bran gave the best quality of carcass in the Wiltshire experiments.

Tainted Bacon.—Distillery refuse gives a watery, soft flesh which glistens when cut. It becomes tainted, and soon goes bad. Kitchen scraps may make the fat too oily. Fish-fed pigs yield a flesh which tastes distinctly fishy.

With regard to fish meal, Green and Richardson[1] found that commercial white fish meal, even when fed in proportion of ⅛th of the ration, may taint the meat of pigs, if included in ration up to time of slaughter.

At the same time, commercial white fish meal of good quality may be fed in moderate quantities (not exceeding ⅛th of total dry food) without danger of tainting the meat, provided its use was stopped at least four weeks before slaughter.

Grading Carcasses.—The following gives the method

[1] Report on Pig-feeding Trials, 1920-23, Lancs County Council.

of classifying dressed carcasses of pigs adopted by Messrs Harris & Co. in the Wiltshire bacon trade:—

	Dressed Weight.	Fat in thickest part of Back.
A. *Highest price* .	130 lbs. to 190 lbs. .	under 2¼ ins.
B. *Second price* .	190 lbs. to 210 lbs. .	under 2½ ins.
C. *Third price* .	210 lbs. to 230 lbs. .	under 2¾ ins.
D. *Fourth price* .	over 230 lbs. . .	under 3 ins.

Soft pigs and small pigs have deductions from scale prices.

Dressed Weight.—Includes everything but intestines, sweetbread, kidneys, spleen, liver, heart, skirt, and lungs. (The feet, head, brain, tongue, and fleck are included.) Shrinkage allowed = 2 lbs. per pig.

Whole Grain v. Meals.—Experiments show that, for fattening purposes, grain fed in the meal form gives better results than the whole grain. *E.g.*, trials at Wisconsin (America) showed that it required 5·01 lbs. maize and sharps to produce 1 lb. live weight increase, while with maize "*meal*" and sharps only 4·71 lbs. were required—a saving of 6 per cent.

Rommel (America) has calculated the results of nine trials, at five stations, and the average amount of whole grain (peas, wheat, rye, oats, and barley) to give 1 lb. live weight increase was 4·73 lbs. When these were ground to a meal, 4·15 lbs. gave the same result—a saving of 12 per cent.

XXXVIII. RATIONS FOR PIGS.

Where separated milk and small potatoes are available, the ration for a pig would, no doubt, consist of these two foods along with suitable meals. The quantities required per pig would depend to a large extent on its size and age, as represented in the following table:—

Typical Daily Ration for a Pig from Six Weeks Old to Twenty-Eight Weeks when Fat.

Age	Meal per day	Separated Milk per day.	Boiled Potatoes.	Approximate Live Weight at end of each Period.
weeks.	lbs.	qts.	lbs.	lbs.
6 to 8	$\frac{3}{4}$	1	...	42
8 „ 12	1	2	$\frac{1}{2}$ to 1	75
12 „ 16	2	3	1 „ 3	112
16 „ 20	3	4	3	155
20 „ 24	4	4	3	190
24 „ 26	5	3	2	210
26 „ 28	6	2	1	224

At this rate a pig would have consumed by the time it is twenty-eight weeks old—

444 lbs. meals.
112 galls. separated milk.
287 lbs. potatoes.

Typical Meal Mixtures[1]—The meal mixtures fed to pigs should not be so rich in albuminoids and oil as the concentrated foods given to fattening cattle or sheep (ruminants), seeing that bulky fibrous foods (hay and straw) are not included in a pig's ration; in fact, pigs have only a very limited capacity for digesting foods high in fibre. Much less labour is, therefore, required to masticate and deal with the food as it passes through the food canal of the pig.

Another point to bear in mind is that the fat in the carcass of a pig is naturally rather soft, consequently the meal mixtures fed should be low in oil, so as to give a less oily and therefore firmer meat.

Skim milk has a costive, and whey a laxative tendency; hence the meal mixture fed with skim milk

[1] Farmers wishing to make up similar meal mixtures should refer to special table of analyses on p. 206.

should have a slightly laxative tendency, and that fed with whey a costive or binding tendency.

The following "standard" for the meal mixture will then be found very suitable:—

Albuminoids, 10 to 15 per cent. Oil, 2 to 4 per cent.
Fibre, less than 6 per cent.

When the meal mixture is fed with whey or water, the albuminoids should, generally speaking, approximate to the maximum percentage (15 per cent.), while with skim or separated milk it may approximate to the lower (10 per cent.).

The ten meal mixtures given below come within the limits of the above standard, and would give good results with an allowance of 1 gall. separated milk per day, or 2 galls. whey:—

With Separated Milk.

1. Barley meal alone.
   $A_{10}O_2F_5$.
2. Barley meal, two parts.
   Oatmeal, one part.
   $A_{11\frac{1}{2}}O_4F_{4\frac{1}{2}}$.
3. Barley meal, three parts.
   Rice meal, one part.
   $A_{10\frac{1}{2}}O_4F_{4\frac{1}{2}}$.
4. Maize meal, one part.
   Wheat bran, one part.
   Barley meal, one part.
   Fine middlings (seconds), one part.
   $A_{12\frac{1}{2}}O_{3\frac{1}{2}}F_{5\frac{1}{2}}$.
5. Maize meal, one part.
   Wheat bran, one part.
   Wheat meal, one part.
   Gram, one part.
   $A_{13\frac{1}{2}}O_{3\frac{1}{2}}F_{5\frac{1}{2}}$.

With Whey.

6. Fine middlings alone.
   $A_{15}O_{3\frac{1}{2}}F_5$.
7. Barley meal, one part.
   Maize meal, one part.
   $A_{10\frac{1}{2}}O_{3\frac{1}{2}}F_{3\frac{1}{2}}$.
8. Maize meal, two parts.
   Coarse middlings (thirds), one part.
   Pea meal, one part.
   $A_{14\frac{1}{2}}O_4F_{4\frac{1}{2}}$.
9. Ground oats, one part.
   Wheat meal, one part.
   Barley meal, one part.
   Bean meal, one part.
   $A_{14\frac{1}{2}}O_{2\frac{1}{2}}F_6$.
10. Dried grains, one part.
    Maize, one part.
    Wheat meal, two parts.
    $A_{13\frac{1}{2}}O_4F_5$.

Food and

Experiments show that 4 to 5 lbs. of meal are generally sufficient to give 1 lb. increase in live weight.

At this rate 1 cwt. meal should give about 22 lbs. (1½ stones) live weight increase.

If carcass weight is taken to be 83 per cent. of the live weight, ¾ cwt. meals should give about 14 lbs. increase of carcass.

It takes about 4 cwts. meals to feed a pig up to seven months of age (say, 165 lbs. live weight).

Approximate Weight of Foods by Measure.

Name of Food	Weight per Bushel	Weight per Gallon.	Weight per Quart.	One Pound Measures.
	lbs.	lbs.	lbs.	qt.
Beans, peas, vetches . .	64	8	2·0	0·5
Wheat	62	7¾	2·0	0·5
Maize, dari, millet . .	60	7½	1·9	0·5
Barley, flax seed, wheatmeal .	55	7	1·7	0·6
Buckwheat, cotton-seed meal	50	6¼	1·6	0·6
Maize meal and cotton-seed meal	47	6	1·5	0·7
Oats, barley meal, and ground linseed cake .	42	5¼	1·4	0·7
Wheat middlings . .	32	4	1·0	1·0
Ground oats . . .	30	3¾	0·9	1·1
Dried grains . . .	20	2½	0·6	1·7
Wheat bran . . .	17	2	0·5	2·0
Malt coombs (cummins) .	14	1¾	0·4	2·5
Potatoes	53	6⅝	...	...
Mangels	45	5⅝	...	...
Swedes	45	5⅝	...	...
Turnips	45	5⅝	...	...
Carrots	40	5	...	...
Wet brewers' grains . .	40	5	...	...
Hay (chaffed) . . .	8	...	...	...
Oat straw (chaffed) . .	5	...	...	...
Oat chaff	2½	...	...	...

N.B.—60 lbs. per bush. = 1⅞ lbs. per qt.; 40 lbs. per bush. = 1¼ lbs. per qt.; 24 lbs. per bush. = ¾ lb. per qt.; 8 lbs. per bush. = ¼ lb. per qt.

'The cost of feeding pigs from birth to eighteen weeks of age would amount to 15s. per head for food alone, while for a seven months old pig the cost of food may vary from £2 to £2, 10s. When looked at from the point of view of carcass, it would cost from 4s. 6d. to 5s. 6d. in food to produce 14 lbs. of increase (pork).

Curing Bacon and Hams

These are generally placed on a stone shelf in a cool, airy room after the hide or skin has been well rubbed with salt. The shelf should have been covered with a thin layer of salt before the bacon or ham is put on it. Salt is then rubbed on the other side, after which a good layer is sprinkled on the upper side. The sides of bacon should be left for at least seven days before they are hung up.

In the case of hams, saltpetre should be well rubbed into the knuckle, and it should be well covered with salt, left for a week, and then rubbed again with fresh salt, and allowed to remain for another week or ten days before it is hung up. Some curers consider it important to use salt which has been heated previously in an earthern vessel, and rubbed well into the hams, as soon as the pig is cut up, preferably before they have had time to get cold.

The bones are sometimes removed, and the bacon placed in a pickle of common salt, saltpetre, and sugar, for two to four days. The bacon is then partially dried, rolled up after it has firmed a little, and then sent out for sale. This bacon is not cured to keep very long.

Wiltshire bacon has the hair singed off in a furnace; it is then placed in a cold room at, say, 42° F., and sometimes a specially prepared brine is pumped into

the blood-vessels by a force-pump. The bacon is then cured with salt, in a slow, mild manner, for sixteen to eighteen days, then dried for a few days, dusted with pease meal, and mildly smoked for a couple of days. Bacon which is chilled before curing is considered to have a better colour.

York and Cumberland hams are placed in salt for two to three weeks. The hams are then washed and afterwards hung up in an airy place, when they dry slowly. When sufficiently firm they may be sold.

An interesting Yorkshire method is to use the following mixture for each small ham of, say, 14 to 16 lbs. in weight, viz.:—1 lb. common salt, ½ lb. bay salt, 1¼ lbs. saltpetre, and ½ lb. brown sugar.

Dry the mixture before the fire, rub down to a fine powder, and rub it well into every part of the ham. Leave four days, then pour over 1 lb. of treacle and leave for three weeks, except that the ham is turned daily, and the pickle rubbed well in. After this period, put ham into cold water for twenty-four hours, then wipe it dry and hang it up in an airy place to dry.

A pickle used for Danish bacon is as follows:—Take 10 lbs. common salt, 1 lb. saltpetre, and 1 lb. dry antiseptic (boron preservative). In winter 1 to 2 lbs. of cane sugar is included. This is stirred up in 4 galls. of water, and the clear liquid decanted off. In some cases the pickle is boiled till it clears.

Sides of bacon are laid on the salting table, the blade bone pocket is filled with dry broad common salt, after which the above pickle is injected by means of a pump. The inside part of bacon is brushed over with the pickle, and then covered with broad common salt. The bacon is left for five to thirteen days; after that it is hung up in an airy place to dry.

Another useful recipe is made as follows:—To each ham, use 1 lb. common salt, ½ oz. saltpetre, 2 oz. juniper berries, ½ oz. pepper, and ½ oz. cloves. Boil in 2 quarts water, and when cold, pour over hams.

Leave under pickle for three weeks, then wash, hang up in air for eight days. Smoke, for three days to three weeks, according to whether the ham is to be used forthwith or kept for several months before doing so.

The following scale of points for bacon and hams are those which are used at the Dairy Show, London:—

Bacon and Hams.

	Points.
Style and workmanship	15
Suitability, *i.e.*, its general proportions	20
Firmness of fat	10
Fineness of rind	5
Colour	20
Flavour, which includes mildness	30
	100

Breed and Carcass Contests at Smithfield.

The following tables (pp. 329-32) give the results of the Smithfield breed and carcass competitions. In the breed competitions the results show what live weights may be obtained at a given age by high feeding. The daily increase from birth of the prize-winners are given, as well as the average daily gain of the whole class.

In the carcass contests the results have been arranged and calculated to give the live weight, carcass weight, and the proportion of carcass to live weight, in addition to the weight of pluck and relative values per 8-lb. stone of the different carcasses.

The figures generally should be regarded as rather high, seeing the pigs were all fattened for exhibition.

Smithfield Show, 1913—Pigs. *Breed Competitions.*

Competitor's No. in Class.	BREED.	Prize awarded.	Age.		Average Live Weight of Two Pigs.			Daily Gain.		Animals in Class.	Daily Gain of all Animals in Class.	
			wks.	days	cwts.	qrs.	lbs.	lbs.	ozs.		lbs.	ozs.
	(a) *Pigs not exceeding Nine Months of Age*—											
488	Middle White	1	38	3	2	1	8	0	15·41	3	1	1·98
491	,,	2	38	1	2	2	23½	1	2·09			
498	Large White	1	37	0	4	0	23½	1	13·04	3	1	7·22
497	,,	2	38	3	3	0	20	1	5·09			
505	Lincolnshire Curly-coated	1	34	6	3	2	10	1	10·25	1	1	10·25
513	Large Black	1	38	4	4	0	16	1	11·39	3	1	7·39
512	,,	2	38	4	3	0	19	1	4·95			
523	Berkshire	1	38	4	3	1	0½	1	5·49	9	1	4·95
526	,,	2	36	1	2	3	26	1	5·04			
522	,,	3	38	0	3	0	23½	1	5·51			
541	Tamworth	1	38	2	2	3	14	1	3·15	4	1	3·24
539	,,	2	35	6	3	1	6½	1	7·55			
552	Middle White × Berkshire	1	38	3	3	2	0½	1	7·23	6	1	6·15
547	,, × ,,	2	38	6	3	1	21½	1	6·56			
550	,, × ,,	3	38	1	3	1	10½	1	6·32			

Smithfield Show, 1918—Pigs. *Breed Competitions*—continued.

Competitor's No. in Class.	BREED.	Prize awarded.	Age.		Average Live Weight of Two Pigs.			Daily Gain.		Animals in Class.	Daily Gain of all Animals in Class.	
			wks.	days	cwts.	qrs.	lbs.	lbs.	ozs.		lbs.	ozs.
	(b) *Pigs above Nine and not Exc. Twelve Months*—											
494	Middle White	1	45	4	3	3	6	1	5·36	4	1	3·10
493	"	2	47	3	3	3	6	1	4·53			
496	"	3	49	5	3	2	5	1	2·25			
503	Large White	1	48	1	4	1	17½	1	7·40	2	1	6·62
504	"	2	50	6	4	1	11	1	5·88			
507	Lincolnshire Curly-coated	1	42	6	4	0	8	1	8·15	4	1	7·35
508	"	2	45	2	4	0	14½	1	7·31			
510	"	3	48	3	4	2	21	1	8·77			
517	Large Black	1	40	5	4	1	20	1	11·37	4	1	9·05
516	"	2	46	2	4	2	25	1	10·12			
519	"	3	48	3	4	2	8½	1	8·21			
535	Berkshire	1	50	2	3	2	25	1	3·00	7	1	4·29
533	"	2	51	5	3	3	5¼	1	2·79			
531	"	3	51	5	4	1	4½	1	5·63			
545	Tamworth	1	47	3	4	2	24½	1	9·44	3	1	5·83
544	"	2	51	3	4	0	21½	1	4·84			
559	Middle White × Berkshire	1	47	5	3	3	22	1	5·17	6	1	3·74
557	" " × "	2	50	1	3	3	23	1	2·91			
554	Large " × "	3	45	1	3	3	14	1	5·97			

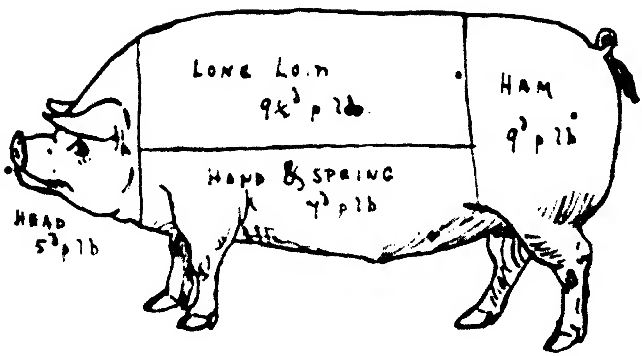
	(c) *Pigs not exceeding* 100 *lbs. Live Weight*—											
567	Middle White	1	17	3	0	3	14½	0	12·74	11	0	12·50
568	,,	2	15	1	0	3	8	0	13·88			
570	,,	3	21	0	0	3	13	0	10·56			
575	Berkshire	1	14	6	0	3	9½	0	14·30	10	0	12·45
573	,,	2	15	0	0	3	15	0	15·06			
577	,,	3	16	5	0	3	9½	0	12·71			
582	Middle White × Berkshire	1	12	2	0	3	12½	1	1·86	7	0	15·44
586	,, × ,,	2	15	0	0	3	10½	0	14·47			
583	,, × ,,	3	12	2	0	3	1	0	16·81			
	(d) *Pigs not exceeding Six Months Old—over* 100 *lbs. and under* 140 *lbs. Live Weight*											
592	Berkshire	1	21	2	1	0	23	0	14·40	6	0	12·65
591	,,	2	22	5	1	0	21	0	13·30			
594	,,	3	21	2	1	0	10½	0	13·01			
	(e) *Pigs not exceeding Twelve Months of Age (Single Pig only)*—											
597	Middle White	1	47	3	3	2	17	1	3·71	8	1	6·51
595	Large White	2	50	0	4	3	24	1	9·32			
596	Lincolnshire Curly-coated	3	38	6	4	0	17	1	11·25			
605	Large Black	1	46	2	5	1	25	1	14·27	6	1	11·11
606	,,	2	46	0	4	3	2	1	10·53			
616	Berkshire	1	47	3	4	1	20	1	5·86	6	1	4·61
614	,,	2	50	2	4	0	8	1	4·81			
618	Tamworth	1	49	4	4	0	6	1	4·93	4	1	2·86
617	,,	2	51	3	3	2	13	1	2·00			
625	Middle White × Berkshire	1	47	5	4	2	17	1	8·95	4	1	5·61
624	Berkshire × Middle White	2	51	4	4	1	22	1	6·07			

Smithfield Show, 1912—Pigs. *Carcass Contests.*

BREED.	Age.		Live Weight.	Carcass Weight.	Percentage of Carcass Weight to Live Weight.	Flank.	Carcass Award.	Price per Stone (8 lbs.)	
One Pig not exceeding 100 lbs. Live Weight—	wks.	dys.	lbs.	lbs.		lbs.		s.	d.
Berkshire . . .	15	2	79	62	78·4	3½	1st	6	8
Large White . .	13	0	93	70	75·2	4½	2nd	6	0
Berkshire . . .	14	4	78	57	73·1	4	3rd	6	0
"	20	4	88	69	78·4	5	4th	5	6
"	16	3	95	74	77·8	5	5th	5	4
"	15	0	87	68	78·1	4	r. & h.c.	5	10
Middle White . .	22	4	92	68	73·9	5	...	...	
Berkshire . . .	20	2	87	66	75·8	4½	...	...	
"	14	6	87	68	78·2	4	...	...	
One Pig not exceeding Nine Months Old, above 100 *lbs., and not exceeding* 220 *lbs. Live Weight—*									
Berkshire . . .	28	5	184	147	79·8	9	1st & ch.	5	10
"	37	0	162	132	81·4	8	2nd	4	10
"	29	6	190	158	83·1	7½	3rd	4	0
Large White Berkshire	35	6	186	152	80·6	4	4th	4	0
One Pig not exceeding Twelve Months Old, above 220 *lbs., and not exceeding* 300 *lbs. Live Weight—*									
Berkshire . . .	50	2	265	216	81·5	10½	1st	4	8
"	43	3	261	211	80·8	10	2nd	3	10
"	46	6	248	210	84·6	9½	3rd	4	2
"	44	1	247	197	79·7	12	4th	3	10
One Pig above 160 *lbs. and not exceeding* 240 *lbs. Live Weight, best suited for manufacture of Bacon—*									
Berkshire . . .	35	1	204	160	78·4	8¼	1st & r.ch.	[illegible]	[illegible]
"	43	3	214	175	81·7	8½	2nd	4	4
Large White Berkshire	35	6	204	168	82·3	7½	3rd	4	6
Large White . .	44	3	273	229	83·8	10	4th	3	10
Berkshire . . .	36	2	208	165	79·3	10	r. & h.c.	4	4
"	31	0	180	145	80·5	8	...	...	
"	33	5	233	202	86·7	9	...	...	

½ cwt. = 56 lbs.; ¾ cwt. = 84 lbs.; 1 cwt. = 112 lbs.; 2 cwts. = 224 lbs.

[illegible]



Relative Prices of different cuts of Fat Pig.

XXXIX. FEEDING SICK ANIMALS.

Horses.

It is rather important for the horse owner to have a fair knowledge of the manner in which horses suffering from any of the commoner ailments should be fed. Obviously the first thing of importance is to know roughly how to diagnose the various ailments, before suitable feeding can be prescribed.

There will be no attempt made here to give anything more than a mere outline of the various ailments of horses, except what is considered necessary to enable one to feed the horse intelligently in the primary stages of sickness. Full accounts must be sought in special works on the subject.

The body temperature of the animal, character of the pulse, and breathing (respiration), often indicate the ailment from which an animal is suffering. If one knows the normal body temperature, the normal pulse-beats, and the normal mode and rate of breathing, then any departure from these either in one direction or the other guides one very considerably in making an accurate diagnosis. Of course some experience is necessary; but if one can only learn to decide when an ailment is serious or not, then this knowledge is most useful.

The normal body temperatures of the common farm animals are all given together, for convenience, in the following table:—

	Respirations.	Pulse-beats.	Temperature.
	per minute.	per minute.	deg. F.
Horse . .	8 to 12	35 to 40	99·5
Ox . .	12 to 16	40 to 60	101
Pig . .	16 to 20	60 to 70	102
Sheep . .	20 to 30	70 to 80	101

The value of each of these indications will be dealt with separately, and in the reverse order.

Temperature.—When the temperature of a sick horse is found to be above normal, it is said to have a fever. Many of these fevers are contagious and require especial care; *e.g.*, influenza, glanders, strangles, etc. To ascertain whether a horse is feverish or not, a clinical thermometer is inserted in the rectum, and as the normal temperature of a horse is 99·5° (Fahr.), an excess of 2° to 8° F. indicates that the horse is feverish. The higher the temperature, the more urgent is the case.

Pulse-beats vary in many respects, and may be grouped as follows:—(a) *Frequent and Infrequent.*—This refers simply to the number of beats per minute, and when the frequency rises ten to twenty beats per minute above normal, this may indicate feverishness; *e.g.*, influenza, strangles, epizootic lymphangitis (weed), or possibly an ailment like flatulent colic. Infrequent and irregular pulses are often associated with diseases of the heart and brain.

(b) *Quick or slow beats.*—These do not refer to the number per minute at all, but simply to the suddenness (jerkiness) or slowness with which the beat takes place. Quick beats are noticeable in cases of anthrax, laminitis, spasmodic colic, etc.

(c) *Hard or soft pulses.*—Some pulses yield to the pressure of the fingers, and are called "soft," while those which only yield to the pressure of the fingers with difficulty, are called "hard." Hard pulses are found in such cases as epizootic lymphangitis, laminitis (fever of the feet), and enteritis. Weak pulses are found in animals suffering from diarrhoea, superpurgation, etc.

(d) *Large or small pulses.*—Small pulses are to be found in laminitis, gastritis (inflammation of mucous membrane of the stomach), and enteritis.

Combinations of these varieties of pulses are common; *e.g.*, frequent and hard, as in epizootic lymphangitis; quick and hard in laminitis; small and hard in gastritis; or persistently small, quick, and hard, as in enteritis.

Respirations.—These may be: (*a*) quicker than normal, as in laminitis, gastritis, spasmodic and flatulent colic, etc.; (*b*) laboured, as in lockjaw, etc.; (*c*) shallow, as in flatulent colic. The breathing may be hurried, as in laminitis, and in some cases spasmodic. Combinations of these are found in the case of flatulent colic, where the breathing is quickened and shallow.

Ailments of Horses.

The many ailments affecting horses may be placed for convenience into four classes, viz.:—(1) fevers; (2) ailments due to errors of diet; (3) ailments due to errors of management; (4) bony diseases. The general treatment in these cases is as follows:—

(1) **Fevers.**—Several ailments of horses are caused by the presence and activity of certain bacteria in the system. As these bacteria multiply in the body they secrete what are known as "toxins," which have an injurious effect on the animal body, causing generally speaking a rise in the temperature of from 2° to 10° F. above the normal. When contact with an affected animal is necessary before a horse can contract the

disease, it is called "contagious," as in the case of glanders; but when the organism is light and capable of being carried about in the air, so that a horse may inhale the organism without coming in actual contact with an affected animal, it is called "infectious," as in the case of strangles. The time which elapses between the intake of the organism and the time when the horse begins to show feverish symptoms is called the "period of incubation," which in the case of glanders varies from three to nine days. To diagnose the particular fever, it is sometimes necessary to examine the blood or affected part microscopically in order to identify the specific organism. External symptoms, such as nose discharges (catarrh), superficial swellings or abscesses, mode of breathing, condition of pulse-beats, etc., would all be taken into account, and are very characteristic.

The part affected may help very considerably in diagnosing a fever; *e.g.*, glanders affects the chest (lungs and air-passages), while farcy chiefly affects the tissues immediately under the skin, more especially the hind leg, where there are generally hard, painful, beaded lymphatic vessels, and unhealthy spreading ulcers. These details are more or less for the expert; but the farmer can easily ascertain with a clinical thermometer whether his ailing horse is feverish or not, and if so, he should at once adopt the following general treatment:—

(*a*) Isolate the affected animal into a warm, well-ventilated box.

(*b*) Disinfect any farm buildings in which the horse has been kept.

(*c*) Give the horse a laxative diet, and something very easily digested, such as a warm "bran and linseed" mash. (For preparation of mashes, see p. 339.)

(*d*) Saltpetre to the extent of ½ oz. per day may be added to the drinking-water or the concentrated food.

For valuable animals it would generally be wise to seek expert advice without delay, but in other cases this treatment may be tried for a short time, to see if the fever abates.

(2) **Ailments due to Errors of Diet.**—These ailments generally affect the abdomen (colic), the legs (weed), or the feet (laminitis), and may be caused by one or more of the following errors of diet:—

(*a*) Giving cold water while the body is hot, or in some cases by watering the horse immediately after the feed of corn, through the coarse, unsoftened oat-hulls being washed into the bowels.

(*b*) Feeding wheat, new barley, and in some cases new oats in comparatively large quantities per day.

(*c*) Giving horses musty and mouldy hay, or hay while in the "sweat."

(*d*) Sudden changes of diet from dry food (hay and corn) to green food (vetches, pasture grass), or *vice versâ*.

(*e*) Giving big feeds to a tired and hungry horse.

(*f*) Feeding too much nutritious food (say, excess of beans), and too little exercise.

Prevention is always better than cure, and probably the most important thing to keep in mind when feeding horses is that "all changes of diet should be gradual." *Sudden changes of diet are always dangerous.*

The general treatment in these cases is :—

(*a*) Keep the animal comfortable and warm.
(*b*) Give a purgative immediately.
(*c*) Feed with nice warm bran mashes, or strengthening gruels (p. 339).

(3) **Ailments due to Errors of Management.**—The ailments falling under this head are: cracked heels, grease, thrush, canker of the foot, mud fever, etc. These may be caused to some extent through allowing horses to stand on heating manure; leaving the legs wet and dirty; washing the legs with cold water, and not drying them; etc.

Treat as follows :—

(*a*) Give a purgative.
(*b*) Clean the wounds and, in case of feet, treat with burnt alum.
(*c*) Feed with light, strengthening food, say, "bran and linseed" mash (p. 339).
(*d*) Saltpetre, ½ oz. per day, may be given to each horse on its food or in its drinking-water.

(4) **Bony Diseases.**—Bony enlargements may be found on the legs of a horse, often causing pain or lameness. The commonest diseases are ringbone, sidebone, splints, and bone spavins. Navicular disease may possibly be included in this group.

These are all hereditary. They may be caused, however, by bruises, sprains, concussion of feet while trotting on hard roads, etc.

The general treatment would be :—

(*a*) Give rest and a purgative medicine.

(*b*) If affected part of foot is hot, it may be immersed in cold water.

(*c*) The diet should be light and laxative.

(*d*) If practicable, let horse run out to grass.

Mashes and Gruels.

The use of mashes and gruels is so important in feeding sick animals, that they may be dealt with here. The food must be easily digestible, very strengthening, strictly limited in quantity, and attractive. Hard, indigestible food should be avoided at such times. It is also important that the food should have a laxative tendency. These conditions are mostly fulfilled in some of the common mashes, provided they have been made with ordinary care.

Bran Mash.—Take 3 lbs. bran and pour over it 3 pints of boiling water, add one dessertspoonful of salt, and stir well. Cover over, leave for half an hour, and feed to horse when cool enough. The horse should not be given more than it is able to clean up each time, as it quickly goes sour, and this does not then improve the horse's appetite.

Bran and Linseed Mash.—For catarrhal affections and ailments of the respiratory organs, linseed should be included in the bran mash. It is at the same time laxative, strengthening, and especially useful in the case of hide-bound animals. In this case ½ lb. linseed, 1 lb. bran, 1 dessertspoonful of salt, are taken and stirred in 3 quarts of water. Boil gently one to two hours, taking care to stir frequently. It may then be fed as a jelly-like mash, or in some cases mixed with nice sweet hay chop.

Malt mashes or malt coombs mashes may be made in the same way.

Linseed Jelly.—This is a very useful laxative that may also be employed with healthy horses at suitable intervals. It can be made by soaking the flax seed in cold water for twelve hours, at the rate of 1 lb. to the gallon of water per horse. The seed should be stirred periodically, and by this time the seeds will have burst, to form a jelly-like mass. Half a pint is sufficient to feed at a time. When it is preferred to boil the flax seed, the seed, at the rate of 1 lb. to 2 galls. water, should be gradually dropped into boiling water and stirred. For drinking purposes, the seeds should be strained off to separate the mucilage part, and the seed residue may be fed with hay chop, either to the same or other horses.

Linseed oil is probably the most convenient and safest laxative for farm live stock. For horses, 2 to 3 tablespoonfuls can be added to the provender night and morning.

Oatmeal gruel will be readily taken by some animals, and is very strengthening. It is made as follows:—take 1 lb. of oatmeal, add a very little cold water till it makes a thick paste, then pour on 3 quarts boiling water. Leave fifteen to twenty minutes, add cold water till the gruel is body-temperature, and allow horse to drink it.

Ground linseed-cake gruel is made in the same way as oatmeal gruel.

Grass, forage crops, and roots have a laxative and cooling effect when available.

When it is necessary to give a horse purgative medicine ("physic") without delay, its action will be all the more certain if it has been preceded with

mashes. A useful purgative in this case would be Barbadoes aloes, made into capsuled balls containing 4 to 6 drachms each.

Ruminants—General Preventions.

Many of the ailments which affect cattle and sheep are brought about either directly or indirectly by the kind or quality of food given, and often in addition through the way in which it is fed. Animals in fairly good condition, generally speaking, resist the attacks of disease much better than those which are in poor condition; it is therefore important to see that the animals are well fed, so as to give them that stamina or vitality which is necessary to resist disease.

Preventive measures are, after all, much better than remedies, and may be grouped under three heads:—

(*a*) Avoid giving foods of inferior quality.
(*b*) The concentrated foods should meet the deficiencies of the bulky part of ration, and be generally suitable for the purpose in view.
(*c*) Sudden changes of diet should be avoided.

Quality deficient.—A large number of the present-day pastures possess a very indifferent herbage, and when sheep and cattle are entirely dependent on such pasturage for their subsistence, the result is that their bodies, being insufficiently nourished, succumb to the ravages of various diseases or ailments.

Highland Pastures.—Sheep fed on certain highland pastures in Selkirkshire (Scotland) suffer severely from louping-ill. The writer examined some of the stretches of low mountain pastures which were said to be "hot-beds" for the disease, and found that the herbage on these stretches consisted very largely of mat grass

(*Nardus stricta*), which has exceptionally hard, indigestible leaves, and there is little wonder that sheep which had to rely on this class of herbage alone for their existence should fall a victim to this disease.

The improvement of land on mountain slopes and high hills is not an easy matter. Sheep, or open drains are sometimes made to drain the excess of water away, and these serve a very useful purpose, but artificial manuring is in a good many cases more or less out of the question on account of the difficulties of hauling, and shallowness of the soil.

Lowland Pastures.—Wet pasture-land abounds with the eggs and embryos of internal parasites, which pull sheep and cattle down in condition very soon, when they are once established in the system. Further, the herbage of wet land consists of rushes, sedges, hard-leaved, indigestible grasses, creeping buttercups, and other acrid plants, etc., none of which is either appetising or calculated to put the sheep and cattle into good condition, consequently they are at a double disadvantage, viz., disease is plentiful, and they are insufficiently nourished to withstand it.

To improve these pastures, drainage is necessary. This alone will tend to improve the class of herbage; but a dressing in winter of basic slag and kainit, or, on soils containing sufficient lime, potassic super, will generally be found necessary to convert the sour, unattractive, innutritious herbage into one which is attractive, sappy, and nutritious. The kainit will encourage the stock to graze the old "fog" off, which is a great advantage.

Apart from the fact that the land carries a larger number of stock, the animals become healthier and thrive much better. In Herefordshire, certain fields

which were very subject to black-leg have apparently been freed by dressing the land with basic slag.

Other foods than grass may be inferior; in fact, hay which has been badly harvested, and cakes which have become mouldy, are much more dangerous than poor grass, and should, theoretically speaking, be avoided. In practice, however, some use must generally be made of them. It is then wise to feed them in small quantities at a time, with much larger quantities of clean and wholesome foods, otherwise digestive troubles will most likely arise.

Concentrates.—When decorticated cotton cake and soya-bean cake—both of which are exceedingly rich in albuminoids—are fed to a larger extent than 4 lbs. per head per day to cattle, say, 18 months old or upwards, there is danger of their suffering from digestive troubles on account of the food being too concentrated. With cattle under this age it is generally best to avoid giving cotton cakes at all. If, however, they are fed in strict moderation and with care, no serious result may follow.

Scouring is a common complaint in the spring of the year, when cattle and sheep feed on young, sappy grass. Concentrates with a laxative tendency would only aggravate the complaint, hence any concentrates fed at this time should have the opposite tendency, and probably no ordinary concentrate is more potent in this direction than Bombay cotton cake. For calves, however, fine wheat middlings should be used in place of Bombay cotton cake.

In the Edinburgh and East of Scotland Agricultural College experiments, sheep were actually fattened off on roots and hay, but the mortality was higher than was the case when concentrates were fed in addition to roots and hay.

On the other hand, "high feeding" is often attended with serious results, more especially with breeding animals. If, however, in-calf cows are kept in too high condition, there is danger of their suffering from an attack of milk fever shortly after giving birth to the calf. In cases where the cows do not actually fall victims to milk fever, their "high" condition often tells heavily against them. The experience of all the best breeders is that breeding animals should be given plenty of fresh air and exercise, and receive sufficient concentrated food to keep them in a healthy state, but not so much as to make them in "high" condition.

Sudden Changes should be avoided.—When cattle or sheep are turned into a field of young clover in the early autumn, it is wise policy to limit them to a few hours' grazing in the afternoon for the first day or two. If the stock were turned into the field in the morning when the dew was on, and left all day, it is more than likely that some of the stock would get "hoven" or "blown."

The same thing applies to turning sheep on to their first "break" of roots in the early autumn; and in order to prevent them "blowing," some farmers sow salt on the first break or two of roots in the morning when the dew is on. The sheep, therefore, get a certain amount of salt with the leaves or tops of the turnips, and it appears to reduce the mortality from this cause very considerably.

The error of suddenly changing the diet is probably the most frequent source of trouble with farm animals, and should be carefully observed by all those persons who have entrusted to them the feeding of farm animals.

A few brief notes are given below for special feeding in connection with common ailments of cattle and sheep respectively.

Common Ailments of Cattle.

Milk Fever.—It is called "milk fever," because in the earlier stages the udder is affected; and "parturient apoplexy," because in the later stages of the disease the brain is affected. It is not, strictly speaking, a fever at all, seeing the temperature does not rise above normal. It does not usually attack a cow till her second or third calf. The following preventions are important.

Cotton cakes and other highly concentrated foods should not be fed too freely to in-calf cows. If a cow is in too high condition, she should be kept on short rations and given occasional bran mashes, or, if necessary, Epsom-salts. If out at grass, it will be necessary to bring her up, and keep her short of food for a few days before calving. It is a good plan to clean the udder out once a week for a month before calving, and it is not wise to remove more than half of the milk each time the cow is milked during the first day, as it gives the udder a rather sudden chill.

Abortion.—Cows should be isolated, and both the cow and the box kept carefully disinfected. Mr Peters, Berkeley Castle Home Farm (Gloucs.), found that it was an advantage to give cows which had aborted ½ oz. crude carbolic acid daily in a bran mash, in addition to the recognised precautionary measures for external disinfection.

Retention of the Cleansing.—With cows that calve somewhat prematurely, the "cleansing" or "afterbirth" may be retained beyond the usual four hours. In such cases the simplest treatment is to give the cow 1½ pints

of cod-liver oil. This usually has the desired effect within twenty-four hours. Another specific is 1 lb. Epsom-salts, ¼ lb. ground ginger, and ¼ lb. ground caraway seeds.

Impaction of the Rumen (first stomach).—This generally attacks cattle which are rather low in condition which have been feeding on poor, bulky foods such as straw and roots, or poor pasture plants, or in fact highly concentrated foods which are fed dry. For a remedial measure give cow 1 lb. Epsom-salts as a drench. A bran and linseed mash could be given twice daily, followed with some oatmeal gruel which has ½ lb. treacle stirred into it.

Impaction of the Omasum (third stomach).—This is also called fardel bound, and is caused in much the same way as impaction of the rumen.

The following very *useful and effective old-fashioned remedy* may be used :—This is made by taking ½ lb. fat bacon and some onions. Both of these should be chopped up into small pieces, and then boiled with 2 to 3 pints of water for twenty minutes to half an hour. While the liquid is boiling, add 6 to 8 ozs. Epsom-salts, ½ oz. ground ginger, ½ oz. saltpetre, 1 oz. common salt, and a little cayenne pepper. After the fat bacon and onions have been boiled sufficiently, take off fire, and stir in 1 oz. of bi-carbonate of soda, and ½ lb. of treacle. When sufficiently cool, drench the cow with the mixture.

This mixture may be used for dairy cows as a general remedy when they are out of sorts. In the writer's experience this remedy has invariably had the desired effect.

Hoven or Blown.—When urgent, the paunch or rumen should be punctured. The mixture for "impaction of omasum" may be given, but the Epsom-salts

and the ginger should be increased by one-half of the quantities named above.

The general treatment for fevers and ailments due to errors of diet, under Horses, apply equally to cattle.

Hoose.—On land where calves are subject to husk or hoose, they should be given dry concentrated food altogether, and if a large proportion of the calves get it each year, they should be kept up at night, and in very bad cases not allowed to go out during the first year, as this disease pulls them down in condition very badly. It is also wise to house them early in the autumn, or provide them with shelter in the field, where they can have hay in addition to cake.

Affected calves should be taken inside, and given nutritious food, and a dose of 2 or 3 teaspoonfuls of turpentine in 1 pint linseed tea, on two successive days. The turpentine then finds its way through the circulation into the lungs, where it comes in contact with the lung worms in the air-passages, thus enabling the calf to expel them by coughing.

If the complaint becomes serious, it may be necessary to inject a suitable solution into the windpipe so as to come more directly in contact with the husk worms. A hypodermic syringe is necessary for this purpose, and enables one after piercing the windpipe between two of its rings, to force 2 drachms of husk mixture into the windpipe three times a day, at intervals of three days. The following is a very suitable mixture for (intertracheal) injection into the windpipe :—

Olive oil	100 parts
Oil of turpentine	2 "
Chloroform	2 "
Pure carbolic acid	2 "

Contagious White Scour.—This disease is due to a specific organism (bacteria), which finds its way into the blood either through the navel or the mouth. In bad cases, the calf's eyes appear sunken about the second or third day after the attack. It takes very little food, commences scouring, and probably dies next day. The end is so sudden that there is not much hope of saving its life when the disease has once got a hold. Remedies are not of much avail in this case, the great thing is prevention on the following lines:—

1. The calf box should be cleaned out and thoroughly disinfected before admission of calves in spring, and at subsequent periods of two or three months. The floor should be well dusted with powdered lime, and the walls lime-washed. The lime-wash should have some carbolic added. Clean litter may then be placed on the floor to make a comfortable bed for the calf.
2. The calf box must be well lighted and well ventilated, so as to assist in the destruction of disease germs. The best arrangement is to have window-ventilators, which are hinged along the bottom. The window then opens inwards and guides the incoming air against the roof before it is reflected on the calves.

   These two preventions were sufficient in the writer's experience to rid the disease out of a dark, unventilated calf box, which was a veritable death-trap for calves introduced into it. But two or three other precautions may be taken:
3. Disinfect the navel of the calf with a 2 per cent. solution of lysol at birth.

4. Avoid gorging the calf's stomach with milk or giving it any milk substitutes for at least two weeks; and after that, any *change in the diet should be made very gradually.*
5. Give calf a tablespoonful of castor oil in milk as soon as it shows signs of sickening or scouring.

Black-leg.—There is considerable difference of opinion with regard to the best preventive means for black-leg. Those who blame the water for carrying the organism into the system of the young cattle believe in fencing off stagnant pools, purifying the streams and the ponds by throwing a few cobs or clots of lime into the water. Others consider it enters with the grass or the hay from certain fields which are favourable to the existence of this organism; hence the grass and hay from these fields should be consumed by older stock. It is generally considered advisable to move young cattle from low-lying fields to higher ground in autumn when fogs are common.

Some pastures which have for many years been considered "hot-beds" for this disease have ceased to be dangerous since the land has been dressed with basic slag, doubtless due indirectly to the improvement of quality in the herbage. Naturally, draining should precede the dressing of basic slag if the land is wet.

Another preventive which is widely used, is a teaspoonful of flowers of sulphur in the concentrated food at weekly intervals during the autumn and winter; while last, but not least, linseed cake is said to be an effectual-preventive against this malady.

There is nothing impracticable about any of these preventive measures. It must be wise policy to provide

water for the cattle free from contamination, to give the pasture a dressing of basic slag and possibly kainit, as well as to feed linseed cake to them.

Sheep Ailments.

Sheep being ruminants require very similar treatment to cattle, but flock remedies have often to be adopted.

Internal Parasites (hoose, liver fluke, louping-ill, etc.).—These appear to be checked considerably by sowing a dressing of salt on the pastures. A lump of rock salt should also be available for them to lick.

With husk and hoose in lambs, turnip tops are very useful, since they contain volatile substances which escape through the lungs into the air and on their way come in contact with the hoose worms, causing them to be expectorated.

Hoven, etc.—Sheep are lost each autumn either from scouring or hoven, more especially when they are turned on to the first break or two of roots or even young clover, where they are tempted to eat too much. In the case of turnips, some farmers sow salt over the first break of roots when they are moist with dew, with the result that their losses from the above cause are very considerably reduced. On young clover the sheep should only be allowed to feed for a very limited period during the first day or two.

Ailments of Pigs.

Pigs which are kept up altogether often become unthrifty, simply because they are not getting the earthy matter and grass which appear to be necessary to keep them in health. A little fresh air and exercise are also invaluable.

Cramp or Lameness.—The results of the Lancs County Council experiments by Green and Nicholson (1920-23) indicate that the inclusion of fish meal in the ration has prevented lameness.

Further, the provision of an ash box containing the following mixture: 5 parts ground limestone, 1 steam bone flour, 1 ground rock phosphate, 3 agricultural salt, and 10 parts coal slack, appears to have been useful in preventing lameness.

Salt-poisoning.—Salt or brine should not, as a rule, be fed to pigs, more especially when they are receiving sharps that are slightly acid, or fatal results may follow through salt-poisoning. Poultry are even more easily poisoned with salt than pigs.

APPENDIX

THE "BOUTFLOUR SYSTEM" OF RATIONING DAIRY COWS, ETC., FOR BIG MILK YIELDS.

MR BOUTFLOUR, while agricultural organiser for Wiltshire, developed a system of rationing and management of Dairy Cows which has had the effect of increasing very considerably the milk yield of cows during the lactation period. In fact, so striking were the results obtained, that the Ministry of Agriculture arranged for Mr Boutflour to tour England and explain his system to organised meetings of farmers.

The economic principle on which the system rests is that, where cows are fed according to milk yield, the lower yielding cows require approximately the same maintenance as higher yielding cows, consequently the more gallons of milk that can be piled on to *one* maintenance ration, within limits, the cheaper will the milk be produced. Reasoning on these lines, Mr Boutflour set himself to develop a system to attain high milk yields, and his system applies chiefly to those farmers who are interested in securing high milk yields from their cows.

The main points included in the system are as follows:—

1. **"The Steaming-up" Process.**—About six weeks before calving, feed 2 to 3 lbs. of concentrated food per head per day, and increase this amount, until a fortnight before calving, up to 6 or 7 lbs. per day. Continue this amount up to a day or two before calving.

The object of this "steaming-up" is to get the cow in good condition before calving, so that she will be better able to stand the heavy strain during her lactation period. The

concentrated food mixture may consist of 1 part decorticated ground nut cake, 2 parts rice meal, and 2 parts palm kernel cake, fed along with, say, 20 lbs. hay and a stone or two of roots.

2. Treatment Before and Immediately After Calving.—If the cow's udder gets uncomfortably full of milk before calving, ease it a little from time to time, by removing part of the milk; then the day before calving, drench the cow with ¾ lb. Glauber's Salts, with a little ginger added, and repeat the dose shortly after calving.

3. Rationing to Force up the Milk Yield.—Give the cow what remains of the milk after feeding the calf, during the first day. Feed the cow with a four-gallon ration, allowing 3 to 3½ lbs. concentrated food per gallon of milk. Two days later, give a five-gallon ration, and continue increasing the ration, till the cow has been forced up to her maximum yield; which is not attained, as a rule, till the sixth or eighth week after calving.

(a) *Control of Bulky Foods.*—An important point in the rationing scheme is to control or limit the amount of bulky food (hay) given to the heavier milking cows, so as to ensure the cow getting her full 3 to 3½ lbs. concentrated food for each gallon of milk given per day.

This may be carried out in the following way:—

Up to 4 gallons,	*allow*	*12 to 14*	*lbs. concentrates*	*and*	*20*	*lbs. hay*
Five-gallon yield,	,,	15 to 17½	,,	,,	17	,,
Six- ,,	,,	18 to 21	,,	,,	14	,,
Seven- ,,	,,	21 to 24½	,,	,,	11	,,
Eight- ,,	,,	24 to 28	,,	,,	8	,,

In some cases, Mr Boutflour has been able to increase the milk yield simply by cutting down the amount of hay which was being fed.

(b) *Control of "Bulky" Concentrates in cases of very deep Milkers.*—When a cow is yielding 7 to 8 gallons of milk per day, it has to consume 21 to 28 lbs. of concentrates per day,

and unless the bulk even of the concentrated food is controlled, it may be difficult to get the cow to eat her full amount of concentrates and keep fit. On this account easily digestible concentrates are selected for each gallon over six, among which may be included fish meal, maize meal, etc.

(c) *Inclusion of Mineral Mixture in Ration.*—Each cow is allowed, say, 1 to 2 per cent. of the following mineral mixture: Two parts of common salt, one part of purified steamed bone flour, and one part of chalk.

(d) *Times of Feeding during Winter Months.*—The concentrates are fed three times a day before each milking, allowing one-third each time; and one-third of the hay is fed after each milking. Should any roots be fed, half these should be fed between the first and second milkings, and the remaining half between second and third milkings. Roots, however, are not considered to be essential.

4. Milking.—The milkers should be efficient and carry out their work in a thorough manner. This involves the keeping of milk records, so that the farmer or supervisor can see if any cow is falling back in her milk yield. As soon as any signs are seen of a cow falling back, the best milker is put on to get her milk yield up again.

The cows should, as a rule, be milked three times a day, as this increases the cow's daily yield half a gallon or even more, and in the later stages of lactation halves the rate of falling off. *Milking times should be, as nearly as possible,* 5.30 to 6 A.M., 1 P.M., and 7 P.M. each day.

5. Importance of a Good and Ample Water Supply.—For heavy milking cows, a constant supply of good water is of prime importance, and wherever practicable, a supply of good water should be laid on to the cow-house, with "nose-bowls" installed, so that the cows can drink freely, whenever they feel inclined to do so.

Where water is not laid on to the cow-house, the cows should be watered after each milking, and in this case a few roots fed last thing at night help to relieve thirst during the night.

6. Summer Feeding.—With good grass and an ample supply of same, each cow receives the usual allowance of concentrates for every gallon over three gallons of milk yielded per day in summer, and over two gallons in autumn.

7. Drying Cows Off.—With the above treatment, cows often continue to give substantial quantities of milk until late in the lactation period, and drying-off is usually essential, if the cow is to have any rest, before the next calving. About two months or so before calving, a milking cow should be dried off, and Mr Boutflour finds it both safe and effective to simply stop milking the cow.

Where the above system is adopted, Mr Boutflour finds it the exception for a cow not to rise to five gallons of milk a day, or for the milk yield to make any sudden rise on being turned out to grass in spring. Further, after the second or third month, there should not be any sudden fall in the milk yield, as is so common, where a proper system of rationing is not adopted. Under this system of rationing, even the heaviest milkers should not lose flesh, and the herds which have been fed on the "Boutflour" system appear ample justification for this statement.

Mr Boutflour has undoubtedly demonstrated how high milk yields can be obtained. There does appear to be some doubt in the minds of certain breeders, as to the wisdom of forcing the milk yield above a certain point, if cows are to continue breeding regularly. In other words, the success or otherwise of a particular system of rationing and management during the year cannot be decided simply on the difference between the cost of foods and feeding, and the value of the milk produced. The cow's regular breeding is an important marketable commodity in the long run.

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